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Feeding and growth of Polar cod in fjords of Svalbard

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Polar cod (Boreogadus saida) were collected in two different fjords around Svalbard in 2006 to address their feeding ecology and growth. Kongsfjorden was sampled in spring and in autumn to investigate seasonal patterns. Billefjorden, which is characterized by more Arctic water masses, was included in the autumn sampling to address impacts by spatial differences in environmental factors as temperature and prey community. The copepods *Calanus* spp were the most numerous prey item at any season and locality. The krill *Thysanoessa* spp contributed for about 30 % of the diet in spring and were at that time the second most dominating prey species in terms of numbers, and likely the most prominent prey in terms of biomass. In autumn the second most dominating prey species had been replaced with the amphipods *Themisto* spp. No clear diet shift was detected, but larger species, as *Themisto* spp and *Thysanoessa* spp, became gradually more important with size. Four age classes were found with age class 1 and 2 being most abundant. Billefjorden was characterized by having almost exclusively young polar cod. In my studies there were also some indications that temperature enhances growth in polar cod. The youngest cohort in Kongsfjorden in spring coincided with the youngest cohort in Billefjorden in autumn, suggesting a lower growth rate for polar cods living in Billefjorden. Temperature also seems to have an effect on abundance. Polar cod were absent in waters over 3° C and in autumn it had been replaced by Atlantic cod at localities where it was found in spring.

Content:

Abstract

1.Introduction

Polar cod (*Boreogadus saida)* is generally considered as a key species in Arctic marine food webs, constituting a major trophic link in transforming energy from lower to higher trophic levels (Gjøsæther 1973, Craig et al. 1982, Falk- Petersen et al. 1986, Lønne and Gulliksen 1989, Jensen et al 1991, Gillispie et al. 1997, Hop et al. 1997, Sæther et al. 1999).

It has a high arctic, circumpolar distribution (Falk- Petersen et al. 1986, Lønne and Gulliksen 1989, Jensen et al 1991, Gillispie et al. 1997) and is the most northerly distributed species of Gadidae (Gradinger & Bluhm 2005). It is widely distributed (Falk- Petersen et al. 1986, Lønne and Gulliksen 1989, Jensen et al 1991, Gillispie et al. 1997) and is found both in ice-free and ice covered areas; especially near ice- edges (Ponomarenko 1964). In ice-covered areas it lives between sandwiched ice floes and in crevices (Falk- Petersen et al. 1986). In areas without ice-cover the adult polar cod are regarded as semipelagic because they are found both pelagic and near the bottom (Hognestad 1968, Gjøsæther & Bjerke 1973). In the first year of living the polar cod is always found near the surface (Hognestad 1968) where they may form upper echo-layers (15- 80 m), while adults are confined to the deeper layers below the thermocline (<3° C) (Falk- Petersen et al. 1986, Olsen 1962).

Polar cod is an important food item for various seabirds, marine mammals and fish species (Haug & Gulliksen 1982) in the high arctic. Seabirds like black guillemonts, kittiwakes, fulmars, murres and brünnich`s guillemonts have polar cod as their main source of food (Lønne and Gabrielsen 1992, Jensen et al. 1991, Bradstreet and Cross 1982, Mehlum et al. 1996, Mehlum et al. 1998), and for marine mammals like ringed seal (*Phoca hispida),* narwhale (*Delphinapterus leucas),* sei whale (*Balaenoptera borealis*), killer whale (*Orcinus orca*), fin whale (*Balaenoptera physalus*), harp seals (Phoca groenlandica and ribbon seal (*Phoca fasciata*) polar cod contribute markedly to their diet (Bradstreet and Cross 1982, Jensen et al. 1991, (Gillispie et al. 1997), Nilssen et al. 1994).

Several authors (Lowry & Frost 1981, Bradstreet & Cross 1982, Bradstreet et al. 1986, Lønne and Gulliksen 1989, Ajiad and Gjøsæther 1990) have characterized polar cod as an opportunistic feeder and it utilizes a broad range of food items (Crawford and Jørgensen 1996). *Calanus* copepods and *Themisto* amphipods are two important prey groups for polar cod (Hop & Tonn 1998) as well as ice-associated amphipods and epibenthic crustaceans (Hop et al. 1997).

Polar cod is small-sized, short lived fish species (Craig et al. 1982, Falk- Petersen et al. 1986, Gillispie et al. 1997, Hop et al. 1997, Christiansen & Fevolden 2000) and can be up to 30 cm in fork length (Hop et al. 1997) or 40 cm in total length (Christiansen & Fevolden 2000). There have been very few recordings of polar cod older than 5 years (Jensen et al. 1991, Hop et al. 1997), but Hop et al. (1997) and Gillispie et al. (1997) have recorded polar cod with a maximum life span of 7 and 8 years, respectively. Amongst the northern gadoid fish species, polar cod has the shortest longevity. Walleye Pollock, *Theragra chalcogramma,* lives up to 28 years, atlantic cod, *Gadus morhua,* up to 16 years and Greenland cod, *Gadus ogac,* up to 11 years are all examples for gadoid fish species with a longer life span than polar cod (Gillispie et al. 1997).

Polar cod has physiological adaptations which makes it possible to live in the extreme and fluctuating environment in the high Arctic and is classified to be eurythermal and euryhaline (Gradinger and Bluhm 2004). It is known to tolerate temperatures ranging from – 1.8° C to 6 ° C (Gillispie et al. 1997) and many places it is subject to sub-zero during most of the year, like in the high Arctic waters of Canada (Hop and Tonn 1998). By living in this environment several adaptations have evolved in high Arctic fish species: tolerance and bioenergetics adjustments to low ambient temperatures (physiological adaptations), hemoglobin in the oxygen transport and cold adapted enzymes (molecular adaptations) (Hop et al. 2002).

My aim for this study was to find out how environmental variability affects the ecology of polar cod. The main focus is feeding ecology and how/if that is altered by abiotic and biotic factors. The environmental factors I focused on in this study were temperature and prey community, differences on a time- and spatial scale. I also wanted to find out how environmental factors, mainly temperature, affected growth.

2. Materials and methods

2.1 Sampling

All the fish and zooplankton were collected during two scientific cruises with R/V Jan Mayen in 2006. The first cruise was from 22th of April to 1st of May 2006 and the second cruise was between 26th of August and 9th of September 2006. The aim was to get samples from two different periods of the year (spring and autumn) and also obtain samples from different water masses. Initially the plan was to do pelagic trawling, but we obtained no catch with the pelagic trawl in the spring and had to focus on benthic trawling. With the benthic trawl we obtained catches from both inner and outer Kongsfjorden in spring, but in autumn we there were only small Atlantic cod (*Gadus morhua*) in the catches from inner Kongsfjorden. I therefore pooled all the data from the two stations (st. 86 and 89, see table 1) in spring and the data from the two stations (st. IK and st. Kb1, see table 1) in autumn. These two stations from each season were taken to be representative for the biotic and abiotic condition at the time when the sampling was done and for the entire Kongsfjorden. In Billefjorden a Multi Plankton Sampler (MPS) was used to get vertical profiles of temperature and salinity and a benthic trawl was taken in the inner basin.

Table 1: Overview of the different trawl hauls

Station	Fjord	Date	Latitude	Longitude	Duration	Depth
86	Kongsfjord	30.04.06	7858.402 N	01059.923 E	20 min	210 m
89	Kongsfjord	30.04.06	7855.230 N	01215.776 E	30 min	146 m
IK	Kongsfjord	06.09.06	7858.869 N	01136.102 E	15 min	319 m
Kb1	Kongsfjord	28.08.06	7858.851 N	01136.638 E	30 min	284 m
Bi	Billefjorden	09.09.06	7839.141 N	01638.686 E	20 min	174 m

2.2 Sampling area

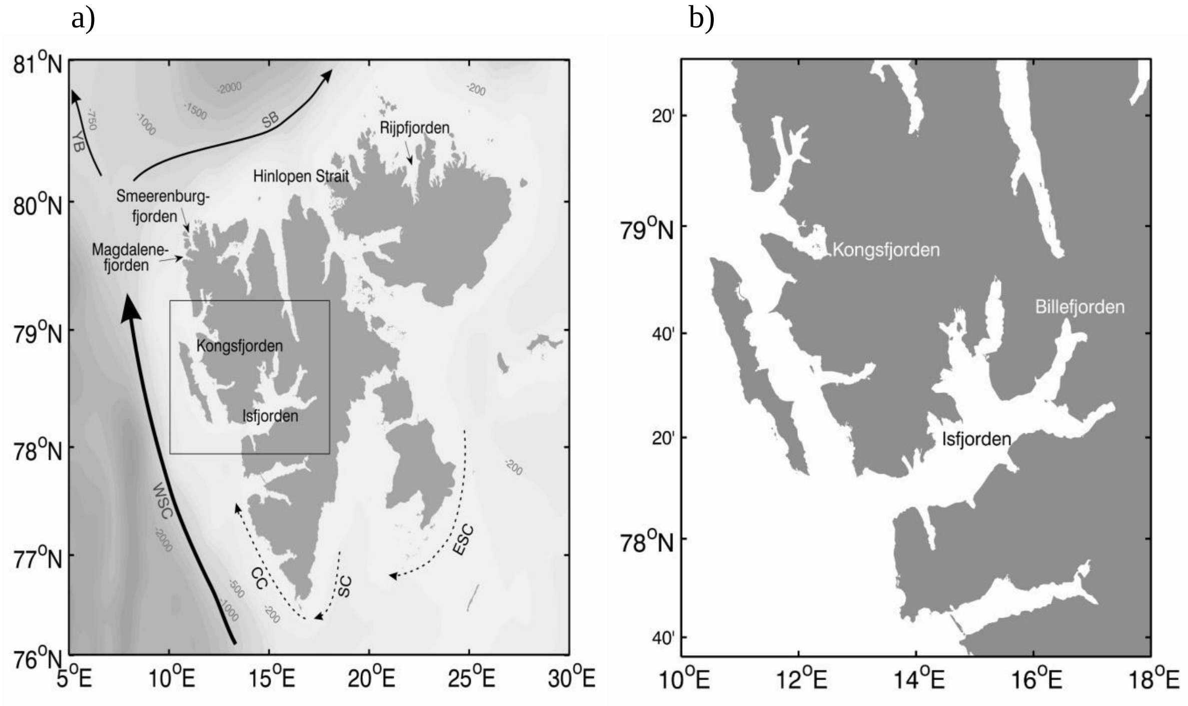


Fig 1: Map showing a) Svalbard archipelago with the different currents. Solid line shows warm (Atlantic) currents and dashed line is cold (Arctic) currents. WSC is West Spitsbergen current, CC is Coastal current, SC is Sørkapp current, ESC is East Spitsbergen Current, YB is Yermarck branch and SB is Svalbard branch. The quadrate is the area of map b) which shows the different fjords sampled in white letters.

Svalbard is a high-arctic archipelago which stretches from around 76° north up to 80° north. Despite its locality at high latitude the western coast of Svalbard is considered sub-Arctic, due to the northernmost extension of the North Atlantic current called West- Spitsbergen current which goes up along the western coast of Svalbard and carries with it relatively warm and salty water. Samples from two of these fjords, Kongsfjorden and Billefjorden, were used to look at differences in the zooplankton community and also the feeding habit of Polar Cod (*Boreogadus saida).*

Kongsfjorden is an open, glacial fjord situated at the west coast of Spitsbergen at 79° N, 12° E and shares its mouth with another fjord, Krossfjorden. Due to the West Spitsbergen current this fjord is considered sub- Arctic and is influenced by Atlantic water. Kongsfjorden consists of two basins separated by a 30 m deep ridge. Samples in early spring and autumn were taken both in the inner and outer basin. There are three large glaciers calving into the fjord and it freezes most winters, even though it has been ice- free the two last winters.

Billefjorden is the innermost part of Isfjorden; a big, open fjord which has its mouth from the western part of Spitsbergen and thus influenced by the West- Spitsbergen current. Billefjorden has two sills; the outer sill has a maximum depth of 80 m and the inner sill a maximum depth of 45 m. The inner sill divides Billefjorden into an outer and inner basin, which is 230 m and 200 m, respectively. Both the WP2 haul and the benthic trawling were done in the inner basin. One large glacier is situated at the head of the fjord and supplies melt water and sediment to the fjord. Billefjorden is ice-covered during winter.

2.3 Sampling methology and sampling gear

Vertical profiles of temperature and salinity were measured with a CTD in Kongsfjorden both seasons and with a MPS in Billefjorden. Zooplankton was sampled by a WP2 net towed from bottom and up to the surface with a vertical towing speed of 0.5 m/s. The WP2 net has an opening of 0,225 m^2 and a mesh size of 200 µm,. Gelatinous planktonic species, which have a tendency to destroy the sample while storing, where taken out before the remaining sample was fixated on 4 % formaldehyde in saltwater for later analyses.

The benthic trawl we used was a Campel 1800 masking trawl with rockhopper gear with an inner mesh size of 20 mm. The trawling speed was approximately 2 nmh^{-1}. When the trawl catch came on deck it was sorted to species, counted and weighted. If the catch of one species was very high, a sub-sample was taken. This sub sample was counted and weighted to estimate the number of specimens in the whole catch. I then took out a 100 random polar cod and these were immediately frozen at approximately -20° C for later analysis.

2.4 Analyses of polar cod stomach

The polar cod were put in a refrigerator the night before being processed to ensure a slow thawing so the quality of the stomach content was as good as possible. The fork length of each fish was measured, the otholits were taken out (for age determination) before the analyses of the stomach content started. Prey organisms were identified to species if possible and each *Calanus* spp found in the stomach were measured for size. Stomach fullness was estimated subjectively according to a scale ranging from 1 to 5 (1=empty, 2= almost empty, 3= half full, 4= almost full, 5=full). The fish was thereafter dried at 105 degrees for 24 hours to establish their dry weights. The otholits were broken in half and then burned for a short period before being analysed under a microscope. This procedure made it easier to count the number of rings in the otholits, representing the age of the fish.

2.5 Analyses of WP2 nets

The fixated WP2 samples were rinsed in seawater before being split into smaller fractions using a Folsom box splitter. The samples were split until the subsample contained approximately 200-300 *Calanus* spp of which each was measured and stage was identified. All the other "big" planktons were identified, preferable down to species level, while the "small" planktons were identified after 10 % of the split fractions were taken out.

Separations of the different *Calanus* spp *(Calanus finmarchicus, C. glacialis, C. hyperborous)* were done based on length distribution of the different copepodite stages.

2.6 Statistics and calculations

All statistical analyses and most of the graphs were done in the statistical package R 2.4.0.

Body condition was estimated from the relationship between length and weight according to Fulton`s condition factor $K= 100*W_D*SL^{-3}$. The mean value of weight was used in each size class.

Weight-at-length comparisons were calculated for the length- classes found in every station and the resulting length-weight relationship for each station determined by the best fitting function $W_D = a*FL^b$, a is a constant and b is the slope value.

The length and weight data were log transformed and the resulting relationship fitted by the generalised least square analysis using weight as a dependent and length as an independent variable.

3.Results

3.1 Hydrography

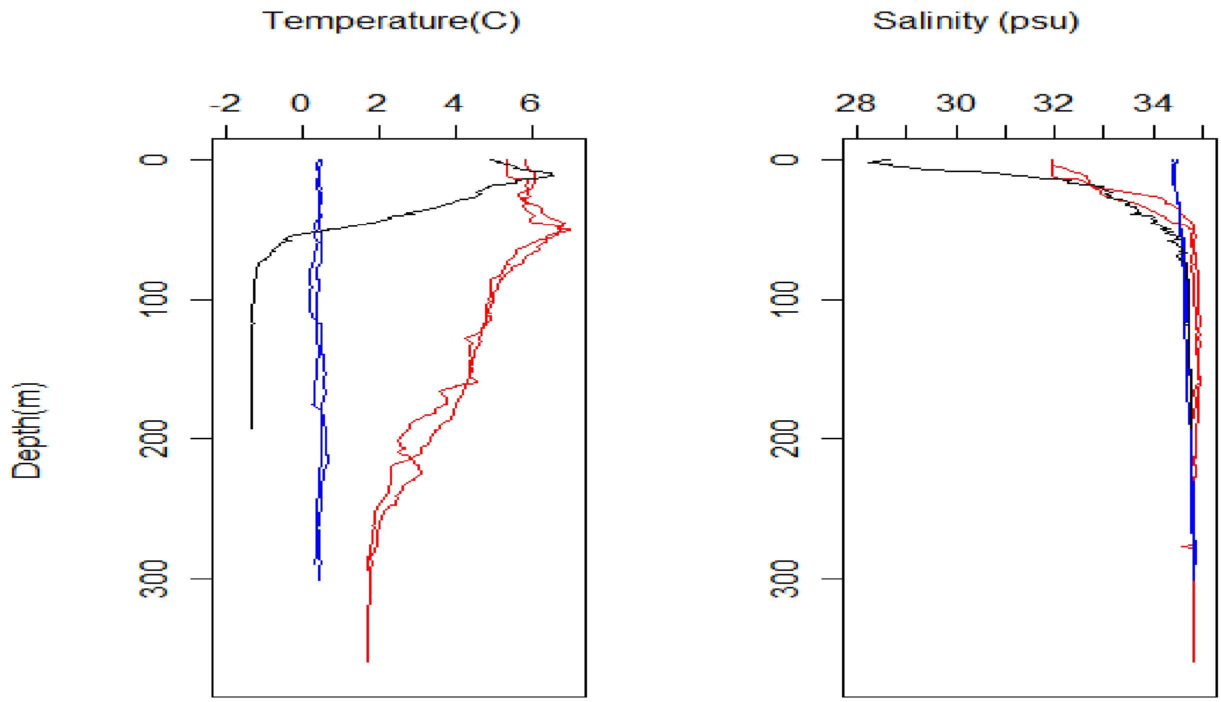


Fig 2: Temperature and salinity profiles for Kongsfjorden. The blue lines are Kongsfjorden in spring, the red lines are Kongsfjorden in autumn and black line is Billefjorden in autumn.

3.1.1 Temperature

In spring, the water masses in Kongsfjorden were largely vertically uniform, with temperatures varying between maximum 0.63˚ C and minimum 0.16 ˚ C. In autumn temperatures in Kongsfjorden increased from 5-6 ˚ C near the surface to nearly 7 ˚ C at around 50 meters, before gradually decreasing with depth reaching a minimum of 1.67 ˚ C at the bottom. In Billefjorden the temperature varied considerably with depth and a termocline was found from approximately 20- 50 meters. (max 6.51 ˚ C, min – 1.37 ˚ C). The temperature rose from surface to around 15 meters where it had its maximum at 6.5 ˚ C. Under 15 meters there was a continuous decrease to around 80 meters and below this depth the temperature was relatively constant at – 1.3 ˚ C.

3.1.2 Salinity

In spring the salinity profiles showed a uniform psu between 34 and 35 throughout the whole water column. In autumn there was stratification in the upper layer (< 50 m) starting at around 32 psu at the surface. Below 50 metres the salinity was uniform at almost 35 psu. In Billefjorden the upper layers only had a salinity of around 28 psu, increasing to around 40 meters, thereafter the salinity was constant at between 34 psu and 35 psu to the bottom.

All the three stations had had the same profiles under 40 meters, varying between 34 psu and 35.

3.2 Zooplankton

3.2.1 Abundance

Table 2: The number of individuals m^3 (percentage proportion) found at the different stations

	Kongsfjorden		Billefjorden
Taxon	Spring	Autumn	Autumn
Amphipoda			
Themisto spp		62(0.006)	2 (0.004)
Chaetognata			
Euchrohnia hamata	0.3 (0.002)	19(0.002)	2(0.004)
Sagitta elegans	1 (0.005)	2(0.001)	5(0.010)
Ctenophora			
Beroe spp	1(0.006)	4(0.002)	
Larvacea			
Oikopleura spp		6(0.004)	
Calanoida			
Calanus finmarchicus	28(0.127)	1244(0.188)	54(0.103)
Calanus glacialis	34(0.155)	551(0.091)	176(0.273)
Calanus hyperboreus	4(0.019)	77(0.017)	9(0.018)
Metridia longa	0.3(0.002)	51(0.010)	21(0.040)
Microcalanus spp	13(0.059)	937(0.142)	103(0.159)
Pseudocalanus spp	47(0.213)	524(0.062)	208(0.321)
Acartia longremis	0(0.002)	9(0.006)	
Cyclopoida			
Oithona spp	54(0.242)	2121(0.413)	60(0.115)
Triconia borealis	6(0.025)	140(0.006)	
Nauplii			
Balanus	4169		
Copepod	1707	9	
Opistobranchia			
Limacina helicina		140(0.024)	
Helicina retroversa		2(0.001)	4(0.008)
Decapod larvae	7(0.032)		

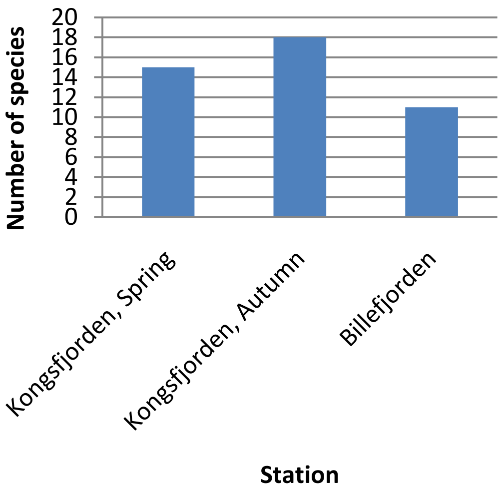
A total of 15 species was found in the WP2 net in spring and 18 species were found in autumn. Billefjorden had the least diverse community with 11 species (Fig 3b)). For both seasons in Kongsfjorden the most abundant was the small cyclopoid copepods *Oithona* spp which constituted almost 25 % of the individuals in spring and 41 % in autumn. In Billefjorden the most abundant specie was *Pseudocalanus* spp which accounted for 32 % of the total catch. Also species from the genus *Calanus* were abundant at all stations; with

Calanus gacialis being the most abundant in Kongsfjorden in spring and Billefjorden, while *Calanus finmarchicus,* by a small amount, was the most abundant in Kongsfjorden in autumn.

Pseudocalanus spp increased markedly in numbers from spring to autumn in Kongsfjorden, while *Microcalanus* spp increased in relative abundance from ca 6 % to almost 15 % in the same fjord.

Some species were only found in one season: Decapod larvae and Nauplii (Balanus) were only present in spring in Kongsfjorden, whereas *Limacina helicina* and *Oikopleura* spp were only present in autumn in the same fjord.

a) b)



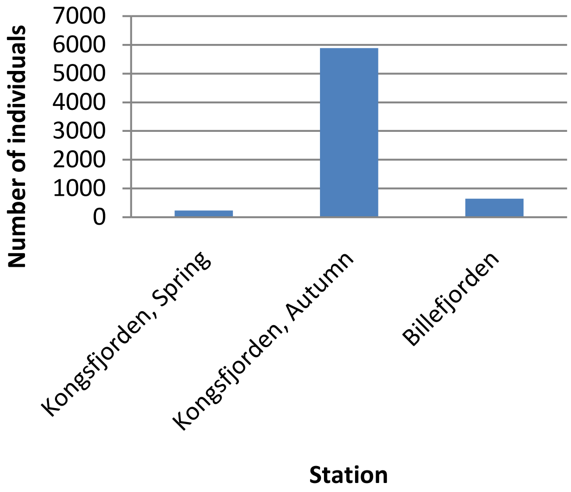


Fig3: a)Number of species b) The number of individuals m^3 water

The number of individulas varied a lot between seasons and localities. Kongsfjorden in autumn had the highest amount of species and by far the highest number of individuals m^{-3}. In autumn in Kongsfjorden there was almost 6000 individulas m^{-3}, compared to around 230 in spring. Billefjorden had the second highest number of individulas m^{-3} with almost 650.

3.2.2 The genus Calanus, abundance and development stage composition

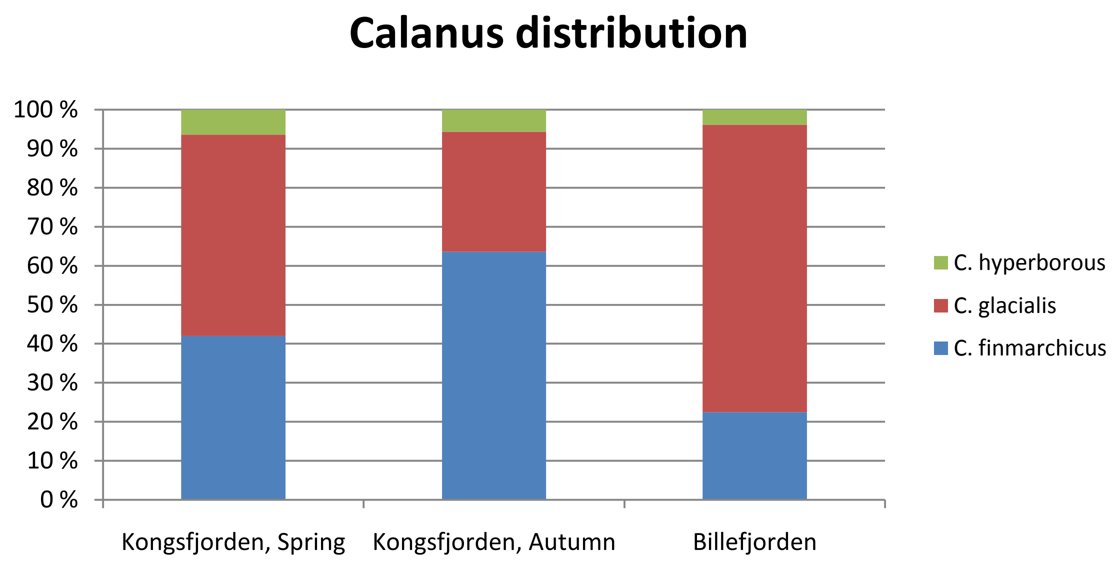


Fig 4: The distribution of Calanus spp at the different stations

In spring *Calanus glacialis* and *Calanus finmarchicus* were equally abundant, and these two species made up over 90 % of the catch. In autumn *Calanus finmarchicus* made up more than 60 % of the catch, while the abundance of *Calanus glacialis* had decreased accordingly. In Billefjorden the most abundant *Calanus* spp was *C. glaciales* and around 70 % of the *Calanus* individuals found were from this species. *Calanus hyperborous* accounted for less than 10 % of numbers at all stations, and had its highest abundance in Kongsfjorden in spring with 7 %.

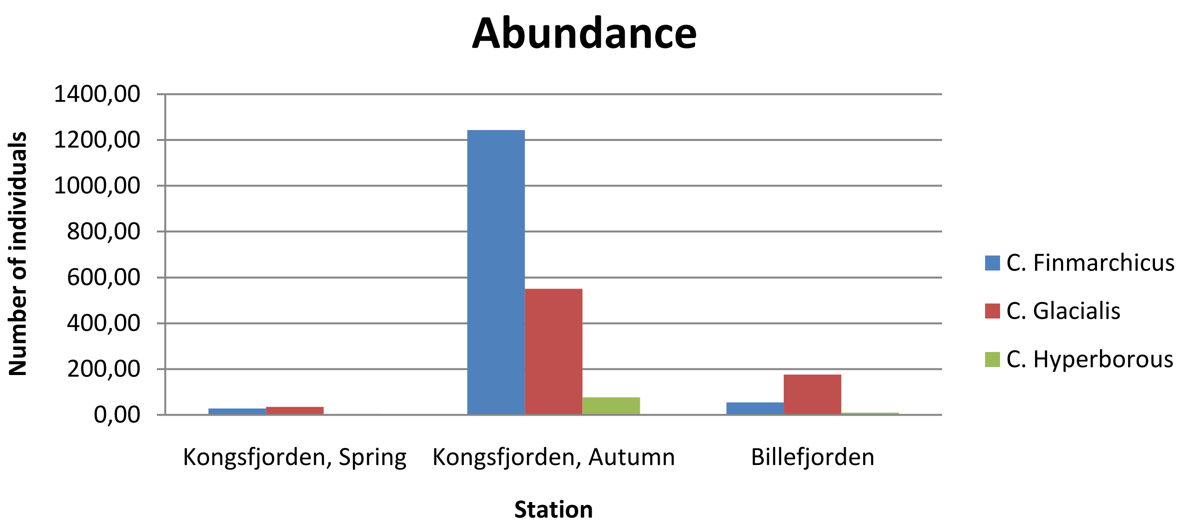


Fig 5: Number of individuals m^3 of the genus *Calanus* at the different stations

There are huge variations in abundance both related to time of year and location.

Kongsfjorden in autumn had the highest abundance of all the *Calanus* species, but the distribution was different from the other fjords. Both Kongsfjorden in spring and Billefjorden had a dominance of the Arctic species *Calanus glacialis*, while Kongsfjorden in autumn had a strong dominance of *C. finmarchicus*. *C. hyperboreus* was found in every station, but in small numbers.

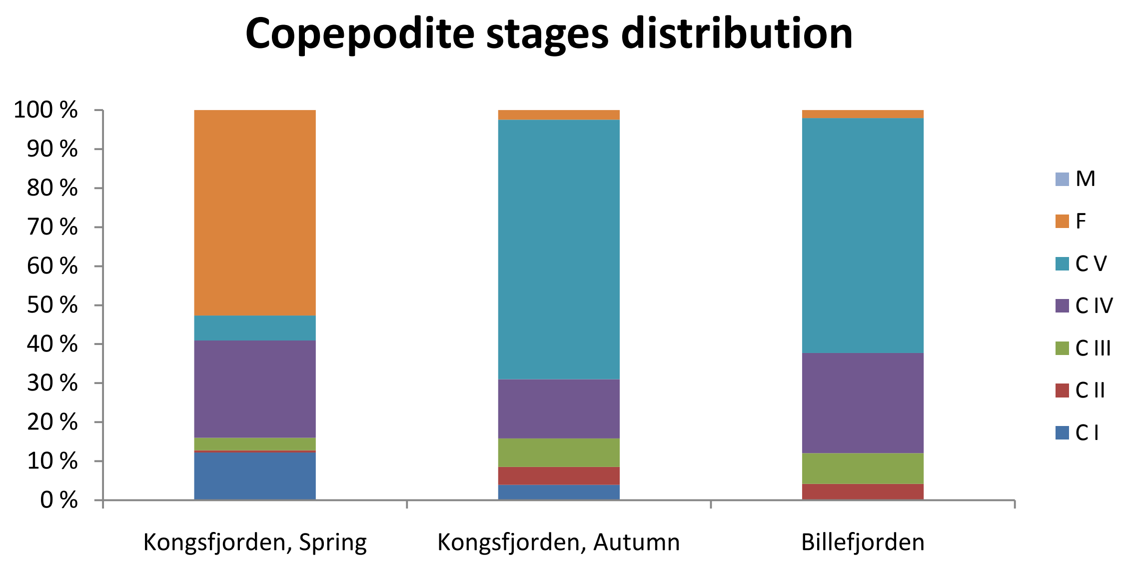


Fig 6: The distribution of the different copepodite stages

In spring more than 50 % of the Calanus spp found were females at the adult stage, around 25 % were at copepodite stage IV and around 10 % were at copepodite stage I. The other stages contributed little to the total abundance. In autumn copepodite stage V dominated both in Kongsfjorden and Billefjorden. In Kongsfjorden it contributed for around 70 % of the total abundance and the amount of females had been reduced to a very small number (< 5 %). Copepodite stage IV made up around 15 % of the *Calanus* sampled and younger copepodite stages (I, II and III) contributed for around 5 % each. In Billefjorden the amount of CV was a little lower, but still this stage accounted for around 65 % of the total catch. Copepodite stage IV had around 25 % and copepodite stage II and III together contributed for a little more than 10 %. Copepodite stage I was absent in the samples.

3.3 Polar cod

3.3.1 Age and size of polar cod

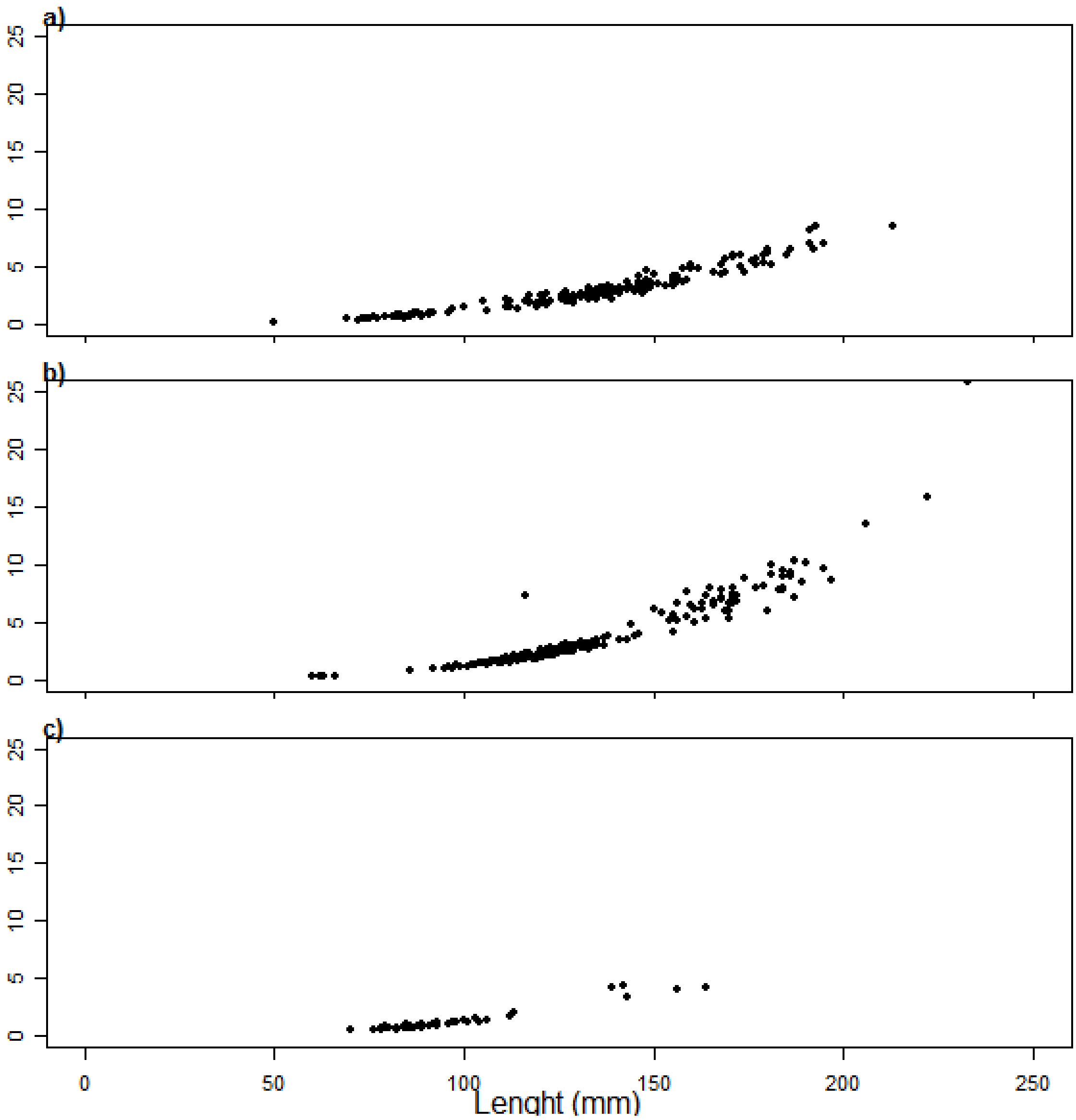


Fig7: Scatter plot showing Length /Weight Relationship a) Kongsfjorden in spring, b) Kongsfjorden in autumn, c) Billefjorden in autumn

The length distribution of fish in spring ranged from 50 mm to 213 mm, with an average of 131 mm. In autumn the length distribution was larger, ranging from 60 mm to 233 mm, with an average of 137 mm. The polar cod caught in Billefjorden were much smaller than in Kongsfjorden with an average of 95 mm, ranging from 76 mm to 164 mm.

The weight distribution showed the same, though more marked trend. In spring the weight ranged from 0.2 gram to 8.6 gram, with an average of 2.8 gram. In autumn the weight of the fishes had increased more compared to what had happened with length. The average was at 4.0 gram and it ranged from 0.3 to 25.9 grams, by far the heaviest fish in my samples. The next heaviest fish was also from Kongsfjorden in autumn with 13.9 grams. In Billefjorden no fish was heavier than 5 gram, with an average of 1.2 gram. The heaviest fish reached the weight of 4.3 gram and the lightest 0.44 gram.

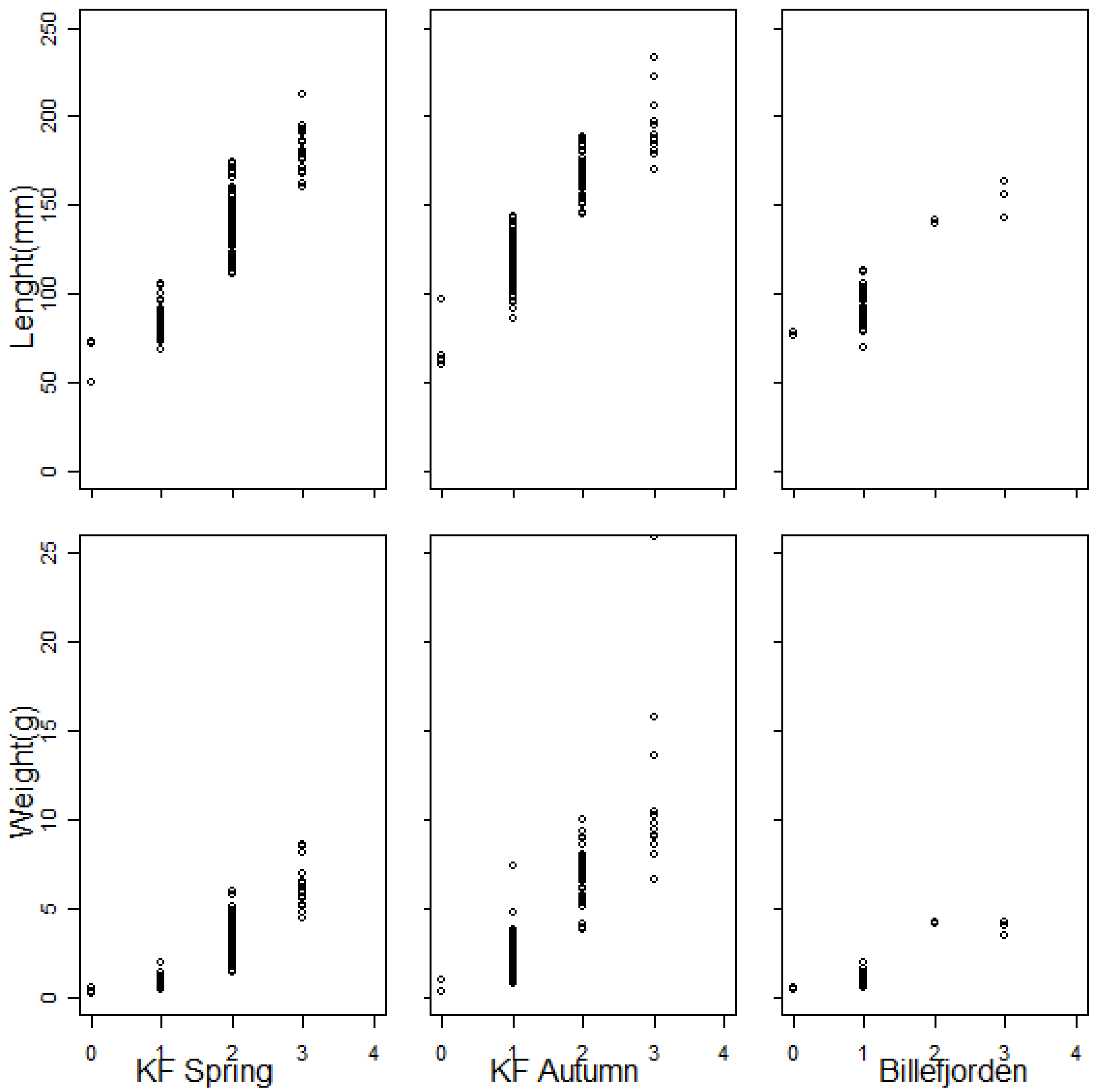


Fig 8: Length and weight at age of polar cod from the different stations. KF is Kongsfjorden.

A total of four age classes were found at the different stations and all age classes was found at each station though in different abundances and size ranges.

In spring in Kongsfjorden the mean length of age class 0 was 65 mm, while the mean length of age class 0 in autumn was 70 mm. And for age class 1 there was an increase in the means from spring to autumn on 34 mm, from 85 mm to 119 mm. Age class 1 had the highest growth of all age classes found. The mean size in length for age class 2 increased with 28 mm, starting at 139 mm in the spring. The last age class found in Kongsfjorden was age class 3 and it had the largest variance. Mean size in spring was 182 mm (162 mm to 213 mm) and in autumn 194 mm (170 mm to 233 mm), an increase only 14 mm.

In Billefjorden the same age classes were found, even though the size span of the different classes varied from Kongsfjorden in autumn. Two fishes at age class 0 were found with a length of 76 mm and 78 mm. 87 % of the polar cods sampled in Billefjorden was estimated to belong to age class 1 with an average of 90 mm, ranging from 70 mm to 113 mm. Age class 2 had two individuals at length 142 mm and 139 mm, while three individuals at age class 3 were found with an average of 154 mm, ranging from 143 mm to 164 mm.

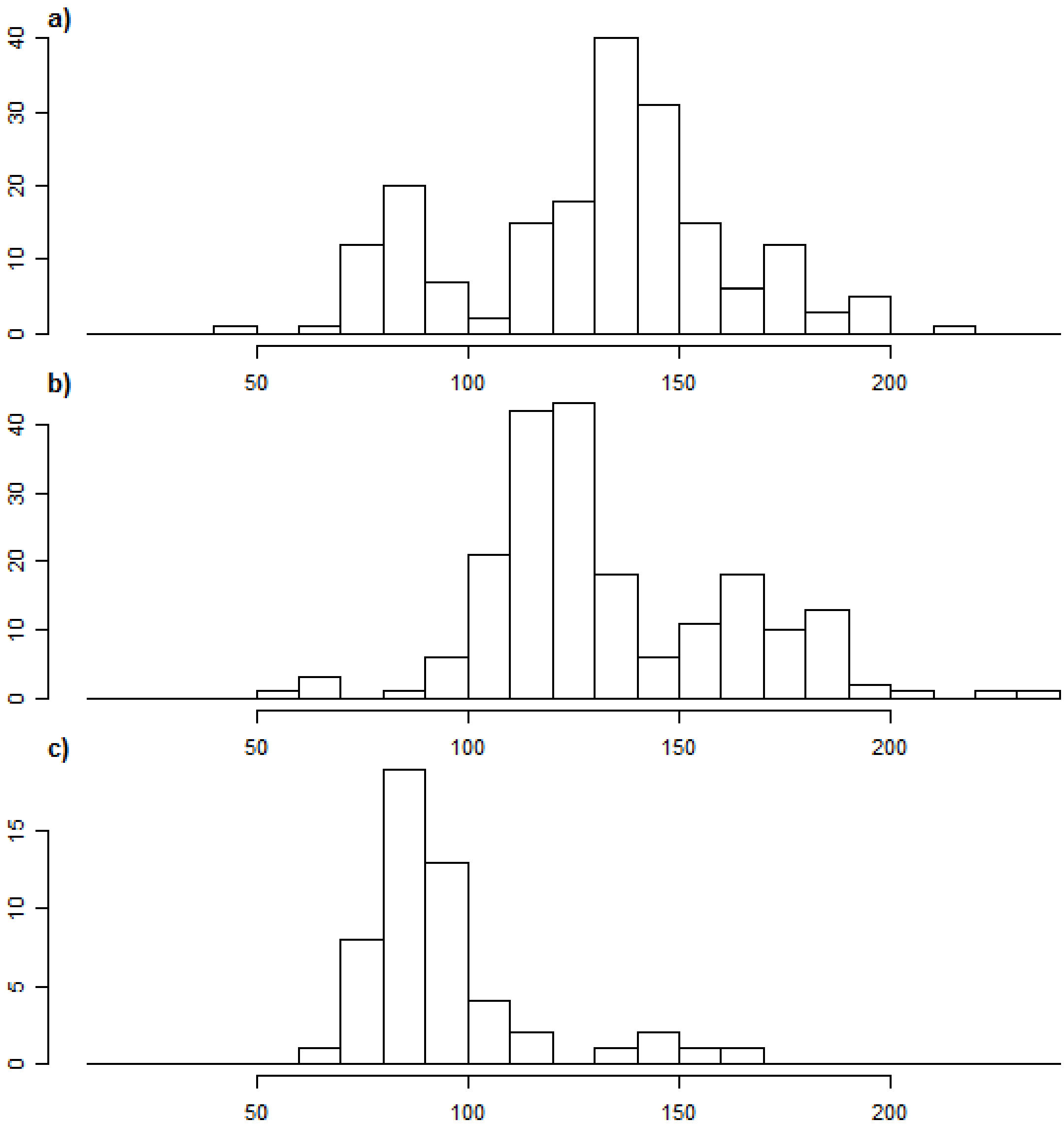


Fig9: Length distribution at the different stations. a) is Kongsfjorden in spring, b) is Kongsfjorden in autumn, c) is Billefjorden in autumn

The length distribution from Kongsfjorden both seasons showed a bimodal distribution, indicating two cohorts. The distribution was also wider than found for Billefjorden. Small fish (<50 mm) were only found in Kongsfjorden in spring and large fishes (>200 mm) were found both seasons in Kongsfjorden, but were absent in Billefjorden.

In spring the first top was from 70 mm up to 100 mm and the other ranged from 110 mm to 150 mm, fading out to 220 mm. Over 50 % of the total number of fishes was found at this second top with the largest number of individuals being around 130 mm (approximately 40 individuals). The total number of individuals caught in Kongsfjorden in spring was 189.

In autumn, peaks were distributed differently than for the spring, being skewed towards larger sizes. Most fishes were 120 mm and 130 mm, over 80 from a total of 198 fishes being in this size range. The second group contained fish from 150 mm up to 190 mm, but their abundance was only around half that of the first group.

In Billefjorden there was one clear top in the size class 70 mm to 110 mm and almost 90 % of the 52 fishes sampled came from this size class. Some fishes were larger and they were evenly distributed around 150 mm. The first major top (70 mm to 110 mm) coincides well with the first top from Kongsfjorden in spring even though the Billefjorden fishes were sampled in autumn, indicating different growth patterns between localities.

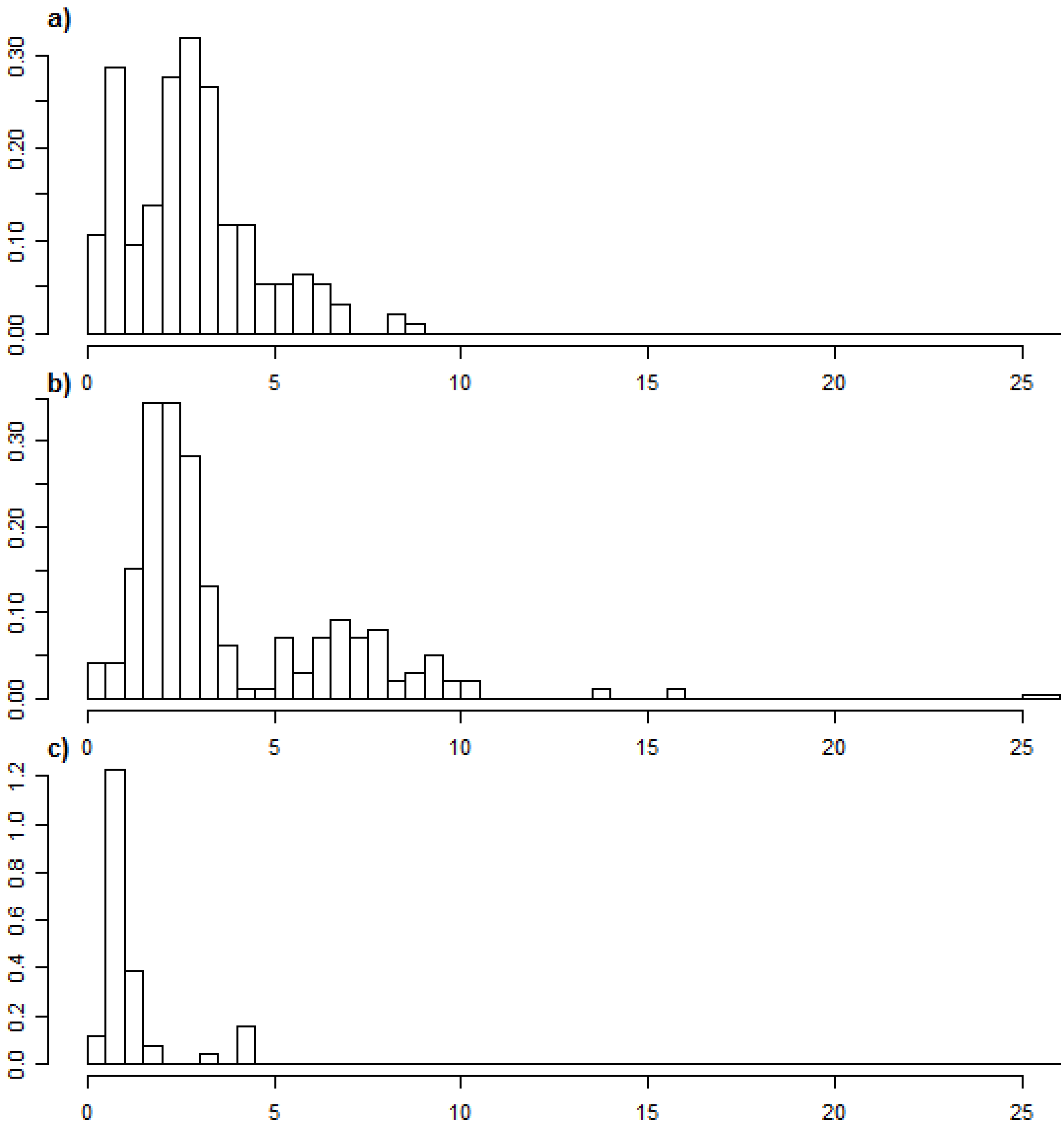


Fig 10: Weight distribution at the different stations. a) is Kongsfjorden in spring, b) is Kongsfjorden in autumn, c) is Billefjorden in autumn.

The weight distribution showed similar trends as the length distribution data, with a bimodal graph for Kongsfjorden both seasons and one clear top in Billefjorden. Kongsfjorden in autumn was the only locality with fishes over 10 gram, the heaviest fish being 25.9 gram. Kongsfjorden in spring had the highest abundance of fish under 0.5 gram (10 fishes), followed by Kongsfjorden in autumn (4 fishes) and Billefjorden (2 fishes).

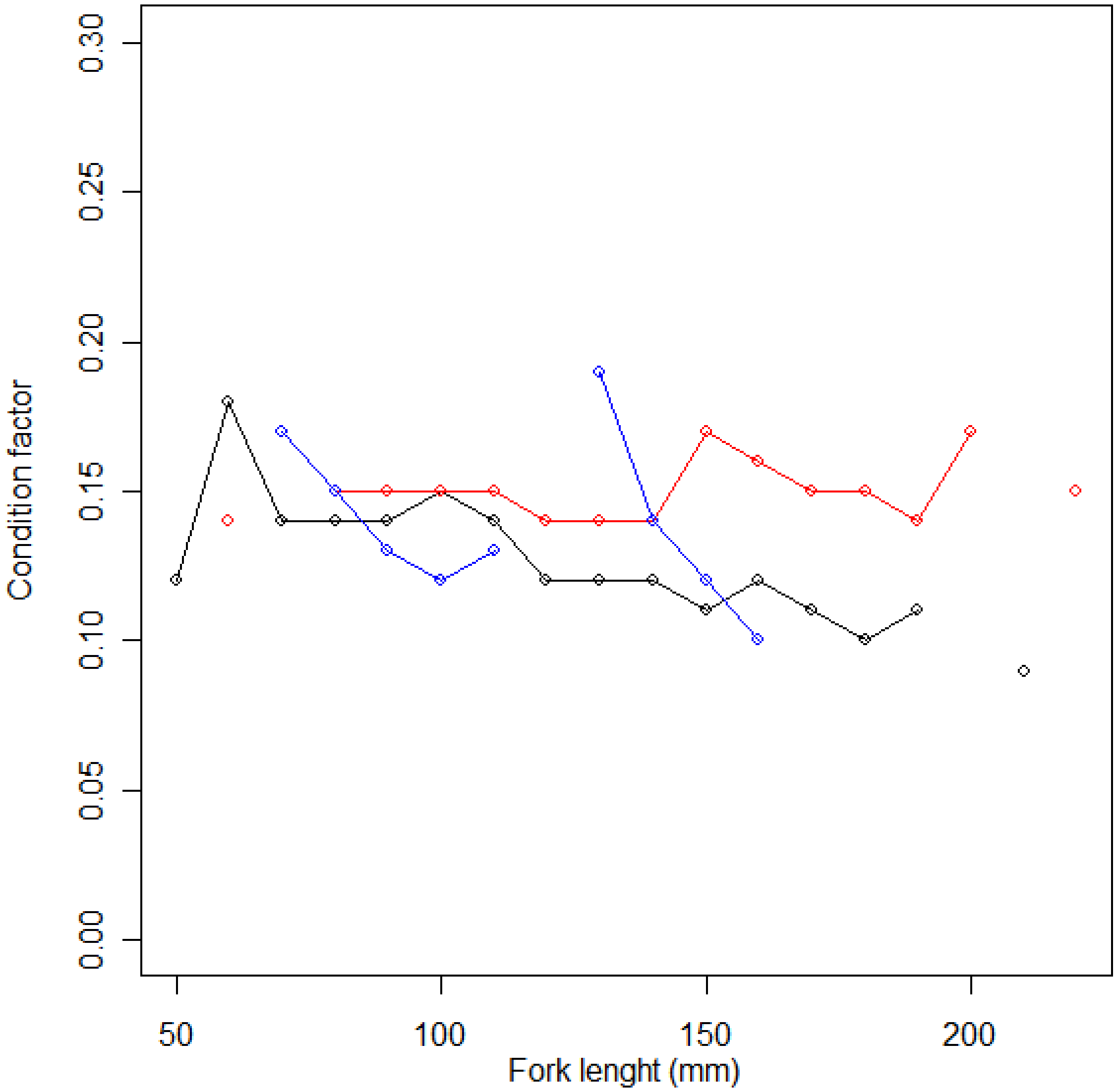


Fig 11: Fulton`s condition factor (K= $100*W_D*FL^{-3}$) for the different length classes at all stations. Black line is Kongsfjorden in spring, red line is Kongsfjorden in autumn and blue line is Billefjorden.

The body condition according to Fulton`s condition factor, K, had more or less the same value at small sized fish, but the differences are more clear at larger sized fish. Kongsfjorden in spring and autumn was significantly different (Welch`s t-test, t= -4.0268, df = 21, $p<0.05$) with fishes having a general higher condition factor in autumn. The condition factor for polar cods in Kongsfjorden in spring had a declining trend with size, while in autumn the condition factor were increasing or at least had the same level with increasing size. In Billefjorden there was no clear trend. The condition factor for small sized fishes declined for individuals from 70 mm up to 100 mm and then increasing again. The number of fishes sampled at larger sizes is, however, low.

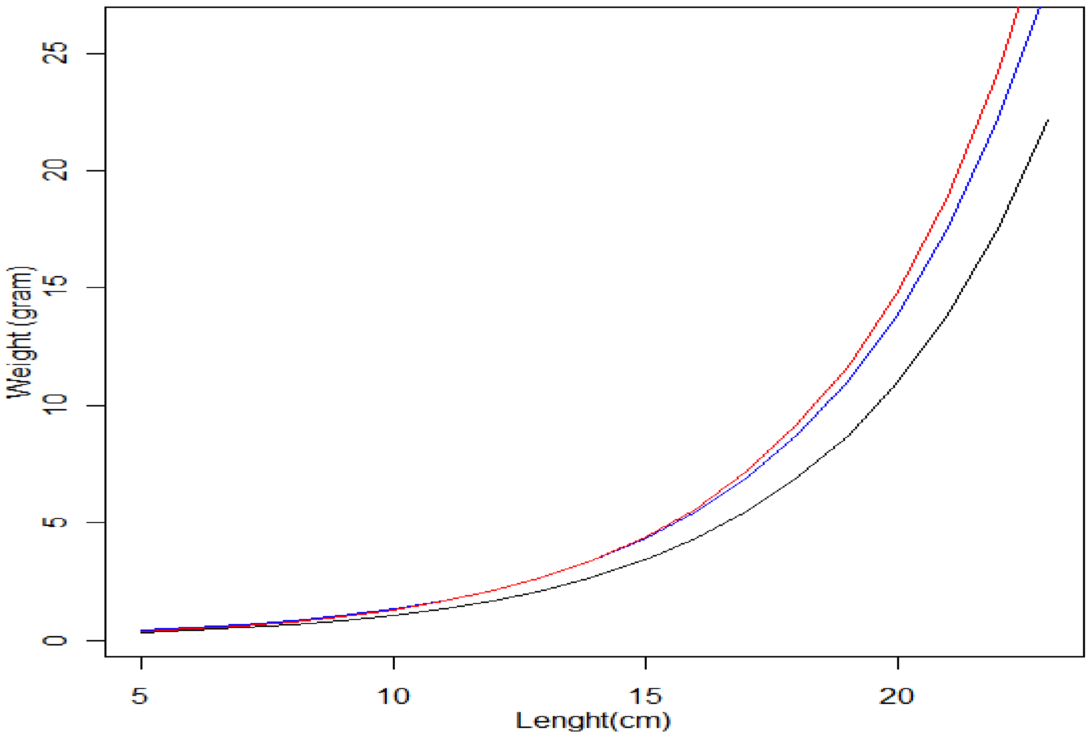


Fig 12: The power function curve describing the relationship between mean dry weight (gram) and standard length (cm). Black line is Kongsfjorden in spring, blue line is Billefjorden and red line is Kongsfjorden in autumn,

The weight differences were mostly emphasized on the big sized fish (14 cm to 20 cm), instead of the small sized fish. Kongsfjorden in autumn had the lighter specimens as indicated by the body condition factor (Fig 11). Kongsfjorden in spring had the worst fit, with an r^2 on 0.93, followed by Billefjorden on 0.94 and Kongsfjorden in autumn with almost 0.97.

Table 2: Estimated parameters for the length-weight realationship

Location	Equation	N	a	b	r^2
Kongsfjorden Spring	$W_D=aSL^b$	189	0.233	2.27	0.935
Kongsfjorden Autumn	$W_D=aSL^b$	198	0.234	2.05	0.967
Billefjorden	$W_D=aSL^b$	52	0.244	2.18	0.942

3.3.2 Diet of polar cod

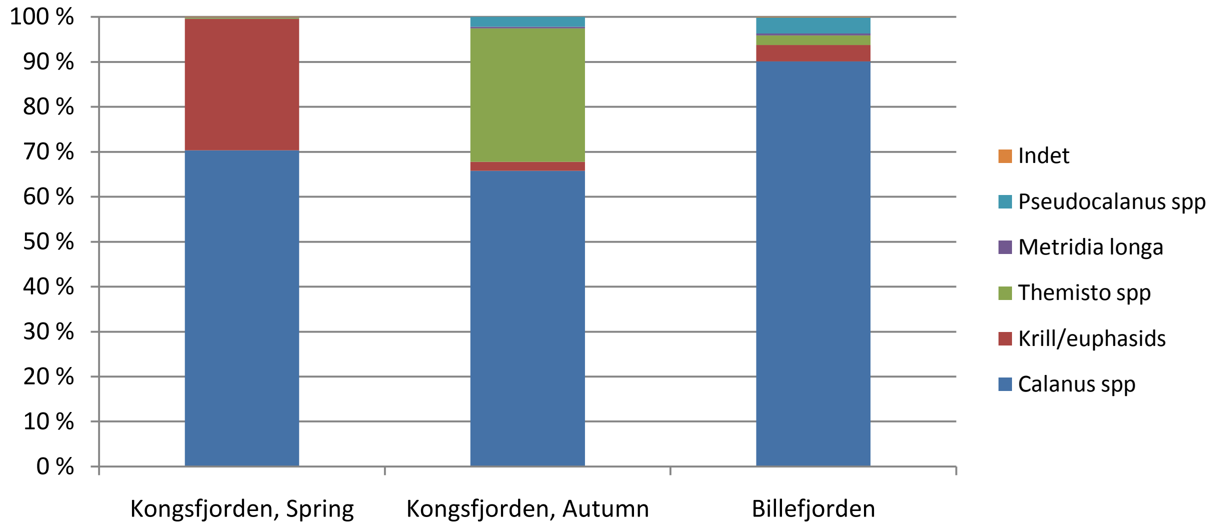


Fig 13: Plot showing what the polar cod have eaten different time of year and different localities. All species with abundance under 0.05 % was removed from the figure.

A total of 17 prey species/genera were found in the stomach of polar cod, but only 3 taxa, *Calanus* spp, *Themisto* spp and Euphausiids spp, constituted for > 95 % of the total number. *Calanus* spp was the most abundant prey in the stomach of polar cod in both spring and autumn, constituting 70 % of the number of prey in spring and 65 % in autumn. In spring the second most abundant prey group in terms of numbers was Euphausiidae spp, constituting about 30 % of the total number of prey. In autumn this part of the diet was almost exclusively replaced by *Themisto* spp, making up almost 30 % of the diet in terms of number. The diet in spring was a little more diverse (14 species), while in the autumn there was only 10 species recorded. In autumn the lesser proportion of *Calanus* spp has been replaced by smaller copepods like *Pseudocalanus* spp, but also Euphausiidae spp.

Stomach normally contained prey, the highest proportion of empty stomachs occurred in spring when 13 % of the stomach did not contain prey organisms. In autumn the proportion of empty stomachs was 8 % in Kongsfjorden and 4 % in Billefjorden.

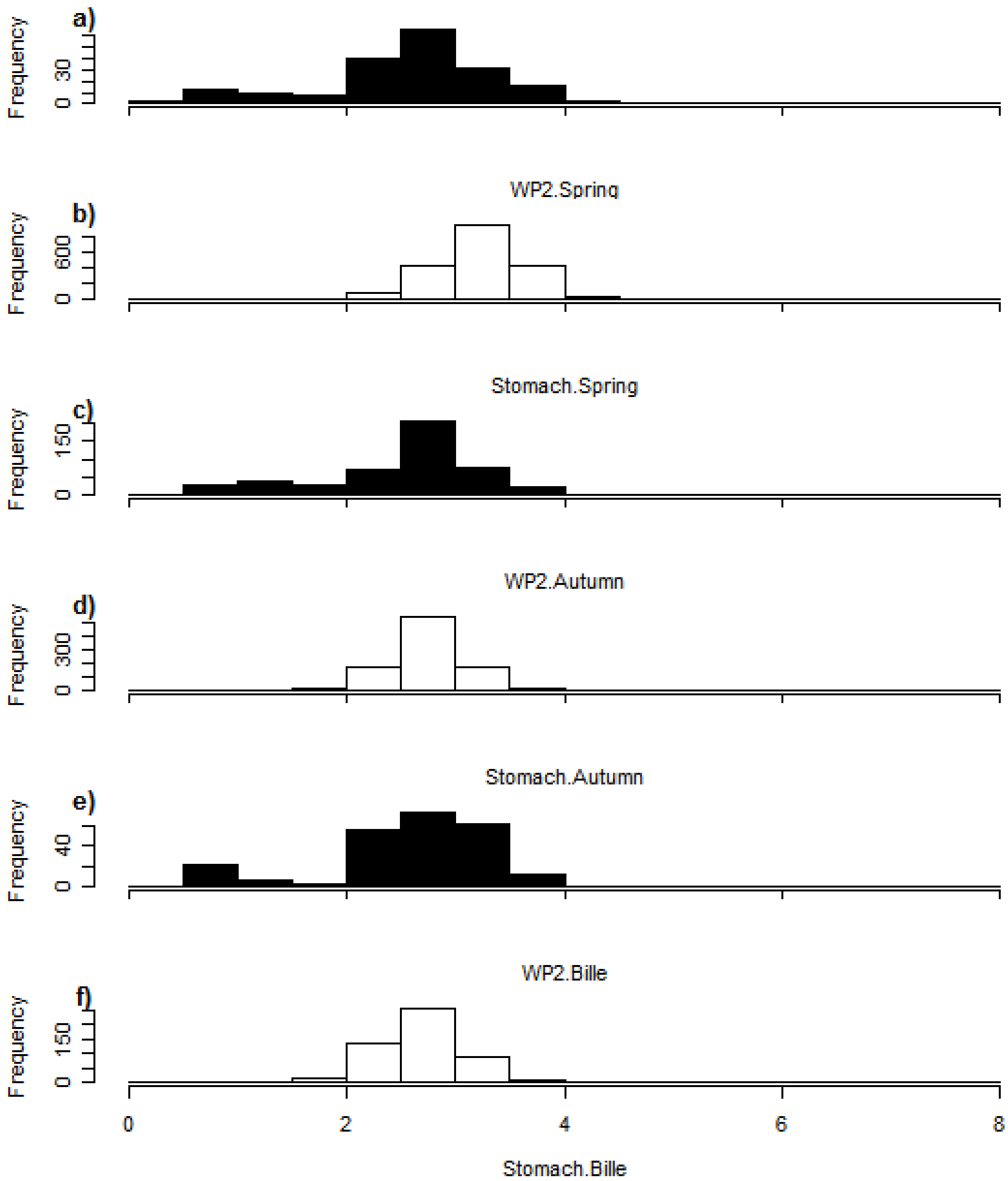


Fig 14: Prosome length of *Calanus* spp found in the WP2 hauls (black) and in the stomach of polar cod (white). a) and b) Kongsfjorden in spring, c) and d) Kongsfjorden in autumn, e) and f) Billefjorden in autumn

Since the different copepodite stages were very difficult to distinguish in the digested stomach content I rather compared length distributions of *Calanus* spp between stomachs and the WP2 samples. The WP2 hauls contained a wider size range than the *Calanus* spp found in the stomach content of polar cod. The *Calanus* species in the stomachs had a size range from about 1,5 mm to 7,25 mm, but the biggest and smallest sizes occurred very seldom. The highest frequency was found from 3mm to 3,5 mm in spring and 2,5 - 3 mm in autumn. The size distribution in the WP2 hauls did not change much between the seasons and the highest frequency was found between 2,5 mm to 3 mm.

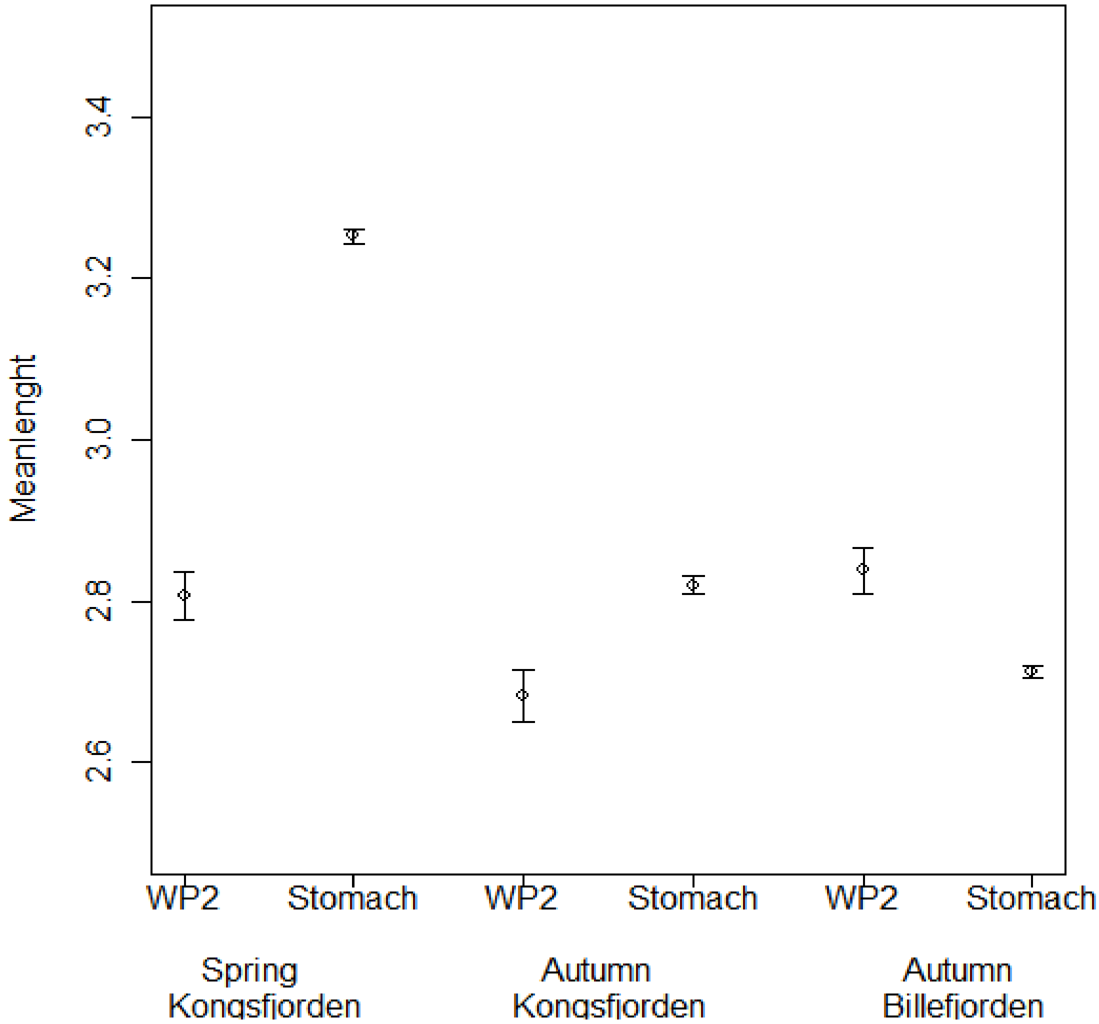


Fig 15: Mean size of the *Calanus* spp found in stomach of Polar Cod and in the WP2 hauls at the different stations. Standard error also plotted. All species shorter 1.56 mm (smallest *Calanus* spp found in the stomach) was excluded from the WP2 hauls.

The highest mean value was found in the stomach of polar cod in the spring, with a gap of about 0, 5 mm between the mean prosome length of *Calanus* spp found in the WP2 hauls (environment) and what was found in the stomach. In Kongsfjorden in autumn there was virtually no difference between mean prosome length in stomach and WP2 hauls, and in Billefjorden the mean prosome length was higher in the WP2 hauls than in the stomach. The WP2 sample and the stomach sample was significantly different at all stations, all the different stomach samples were significantly different from each other and all the different WP2 hauls were not significantly different.

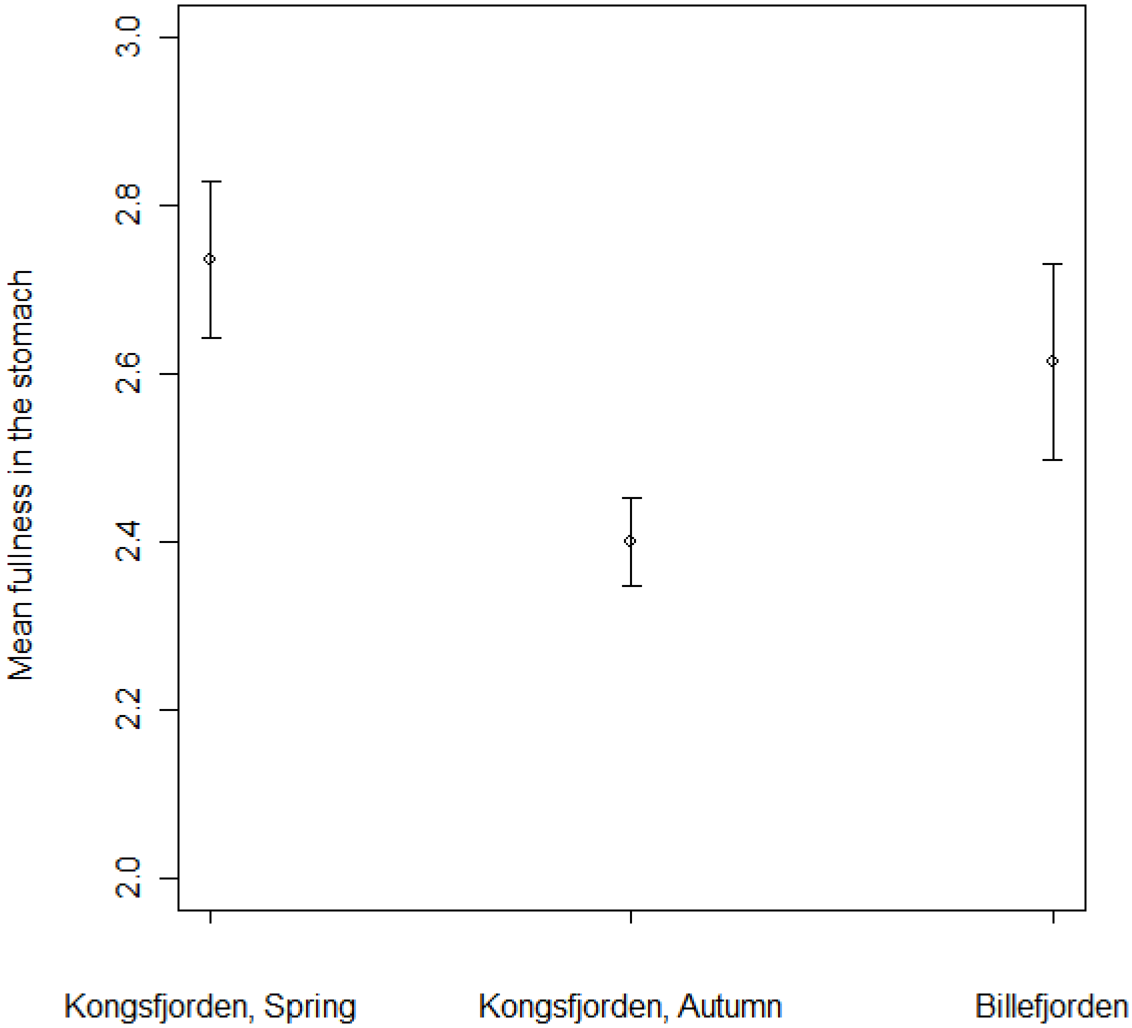


Fig 16: Stomach fullness on a scale from 1 (empty) to 5 (very full) of the polar cod stomach at the different stations. Standard error also plotted.

The degree of fullness in the stomach varied little between localities and ranged from 2.4 to 2.7. Kongsfjorden in spring had the highest value and Kongsfjorden in autumn the lowest value, with Billefjorden at an intermediate level. Even though Kongsfjorden in spring had the highest value, this locality also had the highest proportion of empty stomachs. 13 % of the stomach did not contain prey organisms. In autumn the proportion of empty stomachs was 8 % in Kongsfjorden and 4 % in Billefjorden.

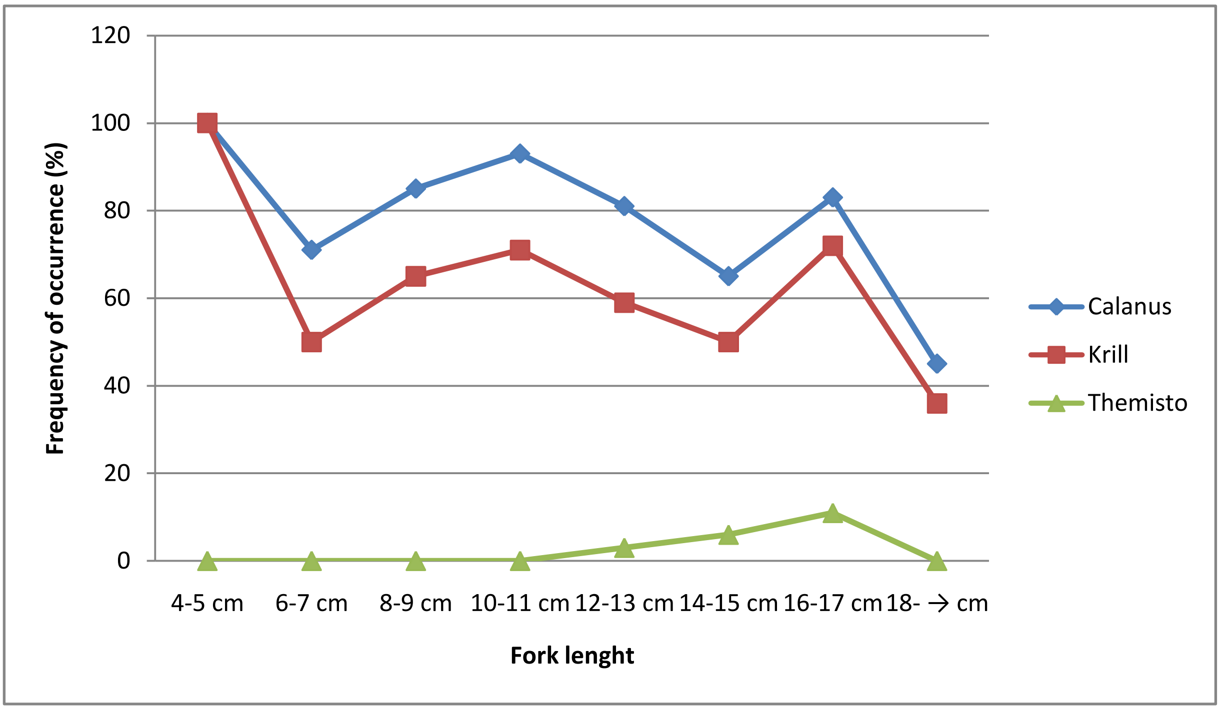


Fig17: The diet of polar cod in Kongsfjorden in spring, as indicated by the percent occurrence of the three main prey species for different cod size classes

In spring the main prey for polar cod was, as pointed out earlier, *Calanus* spp and Krill. There is no indication for a diet shift in polar with age, yet a trend that the importance of larger prey (Krill and *Themisto* spp) increases with size. The proportion of empty stomachs increased with size.

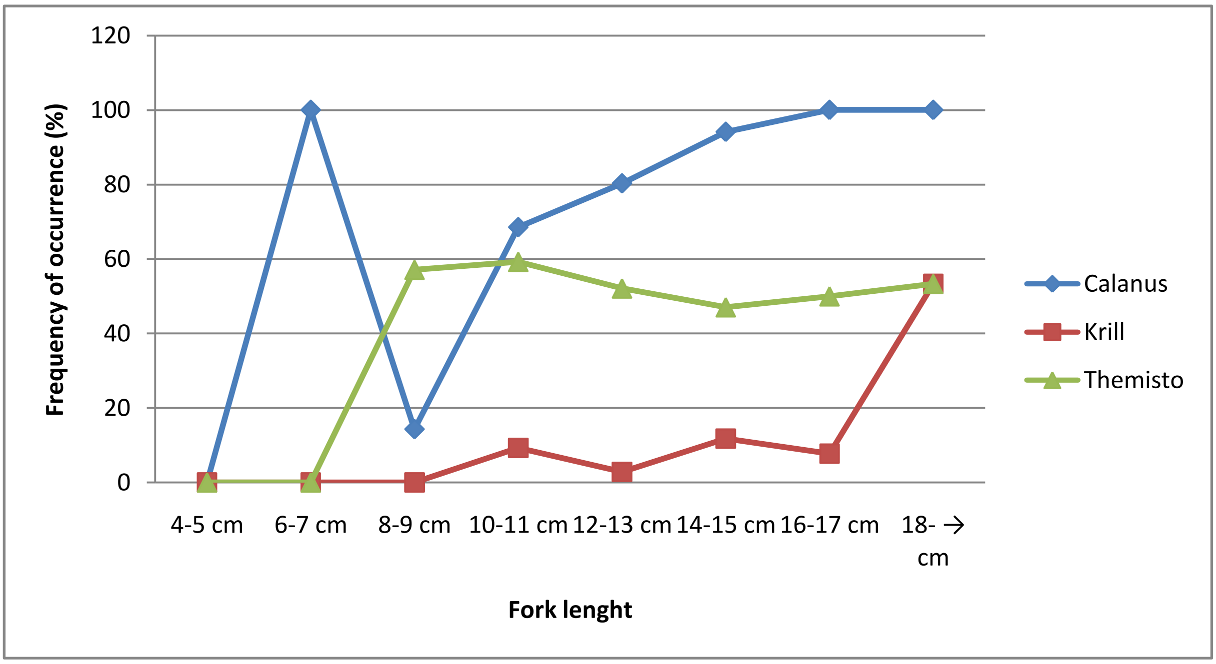


Fig18: The diet of polar cod in Kongsfjorden in autumn, as indicated by the percent occurrence of the three main prey species for different cod size classes

In Kongsfjorden in autumn there is a clear shift between *Calanus* spp and *Themisto* spp at size group 8-9 cm, but the dominance of *Calanus* spp was clear already in the next size group. The results may not be representative due to low sample number (6 individuals) for this size group. The frequency of occurrence of *Themisto* spp is relatively constant at around 50 % from this size group and larger groups. Krill is becoming somewhat more important in larger size groups.

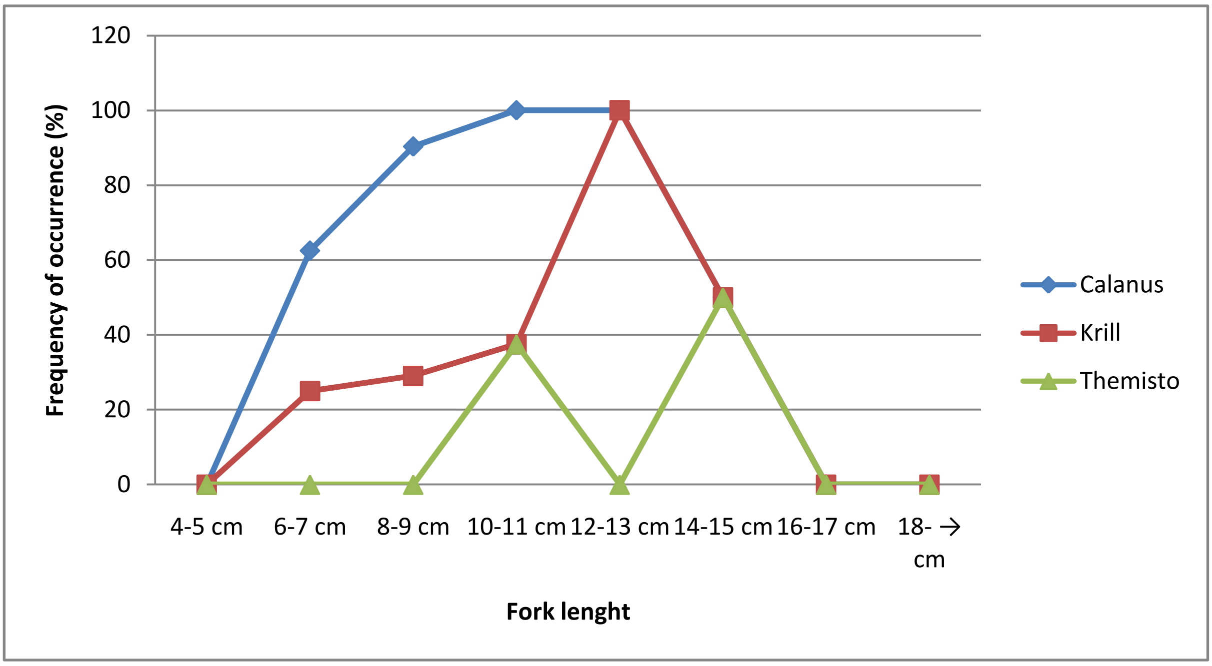


Fig19: The diet of polar cod in Billefjorden in autumn, as indicated by the percent occurrence of the three main prey species for different cod size classes

In Billefjorden the dominating species was *Calanus* spp for all size classes, but the number of fish larger than 11 cm was too low to be representative.

4. Discussion

Length and weight data are widely used in fish ecology studies and are essential for estimating growth rate (Kohler et al. 1995, Morato et al. 2001).

In my studies there were big differences in size from the different localities and seasons; different cohorts dominating in different hauls. In Kongsfjorden both seasons two distinct cohorts were recognized and there was one main cohort from Billefjorden. The largest fishes were found in Kongsfjorden both seasons, but the amount of cohort 2 had decreased in abundance in autumn (Fig 9), suggesting a higher mortality on this size range or migrations away from the sampling locations. In Billefjorden in autumn the sample almost conclusively consisted of fishes ranging from70 mm to 100 mm and only a small number of fishes had the length range 150 mm ± 20 mm (Fig 9). Hop, Welch and Crawford (1997) pointed out that age distribution in samples depended on gear selectivity, but this trend is not clear in my samples. The different stations were trawled with the same gear and consisted of different cohorts. In Chukchi and Beaufort seas small fishes were more common in water less than 100 m deep (Lowry and Frost, 1981). This coincides partly with my studies since Billefjorden, which was the shallowest trawling station, had the smallest sized fishes.

Polar cods from Billefjorden seemed to have a slower growth than polar cods from Kongsfjorden, since the youngest cohort in Kongsfjorden in spring coincides with the youngest cohort in Billefjorden in autumn (Fig 9, Fig 10). Craig et al. (1982) showed that polar cod might have better growing conditions in warmer coastal waters than offshore waters and Jobling (1997) underlines that fish growth is markedly influenced by water temperatures. The digestive processes in polar cod are very slow at sub-zero temperatures so even if the food supply is abundant the slow metabolic rate will limit the food intake and growth. Hop and Graham (1995) pointed out that stomach evacuation time for polar cod in sub- zero temperatures is up to 2 weeks.

Gillispie et al. (1997) showed that in the north-eastern Chukchi Sea conditions for growth of polar cod was more favorable the “warm” year 1990 than in the colder year 1991, and more generally polar cod may belong to those fishes whose growth is favored by warmer years compared to colder years in the Chukchi Sea (Springer et al. 1984, Gillispie et al. 1997). My data indicate a favorable effect of warmer water on the growth of polar cod. Warmer water may also influence other qualities of the environment, like prey concentration. In my studies the concentration of prey was higher in the warm water in Kongsfjorden compared to Billefjorden (Fig 3b) and this might have contributed to the higher growth observed in warmer water localities as Kongsfjorden. As mentioned above the gastric evacuation rate is faster in warmer water (Hop and Tonn 1998), indicating that polar cod might utilize more prey items and grow faster.

Hop and Graham (1995) pointed out that this could be an advantage for polar cod, since in periods of feeding the fish would have a high growth capacity and also low weight loss during periods of starvation.

In my samples 4 different age classes were recorded ranging from 0 to 3 years old. Age class 1 was the most abundant followed by year class 2. The study of Lønne and Gulliksen (1989) from western Barents Sea and north of Svalbard, and the study of Jensen et al. (1991) from western Barents Sea both only sampled age class 1 and 2, suggesting that these classes might be the most abundant in the area. There were differences between the same age classes found in spring and autumn in Kongsfjorden due to the obvious fact that polar cods grow during summer.

The period between these two samplings was approximately 120 days and a simple estimation of the growth rate shows that the highest growth was observed for age class 1, with an estimation of 0.28 mm day^{-1}. Age class 2 and 3 followed with 0.24 and 0.10 mm day^{-1}, respectively. Age class 0 only recorded a growth of 0.04 mm day^{-1}, but the number of specimens of this age class was low (Appendix 2). Even though Gjøsæther and Ajiad (1994) pointed out that length-at-age is not a direct measurement of growth within a specific year, but represents accumulated growth over two or more growth seasons it can be argued that specific growth rate is a good measurement for differences between different year classes within a year.

Studies of age at length- and age at weight of polar cod have been conducted by several authors (Olsen 1962, Falk- Petersen et al. 1986, Lønne and Gulliksen 1989, Jensen et al. 1991, Hognestad 1968) and some of these results compare poorly with my findings. They found more age classes at the same length interval and these huge differences are hard to explain only by environmental or genotypic differences.

The length of polar cod found from literature has been fluctuating from years to years. Gjøsæther and Ajid (1994) measured length of polar cods for three conspicuous years in the Barents Sea, and the mean value of length for age class 1 ranged from 10.9 cm to 12.5 cm, which is the highest recorded mean length of age class 1 in the literature. The lowest mean value of age class 1 from the literature is 8.2 cm (Lønne and Gulliksen 1989, Jensen et al. 1991). Age class 2 mean length ranges from the literature spans from 10.9 cm (Lønne and Gulliksen 1989) up to 14.9 (Hognestad 1968). Lønne and Gulliksen (1989) found a difference in the mean length between the western Barents Sea and north of Svalbard of 2 cm for age class 1 and 1.6 cm for age class 2 in the same year.

My comparable samples, the samples taken in autumn, showed some different results than those mentioned above. The mean for age class 1 was 11.2 cm, which is within the length range found by several authors, but there is a big difference for age class 2. The mean length for age class 2 in my study was 16.5 cm, being more than 1 cm longer than any previous record. Colin Griffiths (pers. comm.) had a mooring situated in Kongsfjorden the whole year and he has reported of ice- free conditions throughout winter and massive influences of warm Atlantic water during summer and autumn. The von Bertalanffy equation for growth was fitted to the data set, but the outcome made little sense.

According to Craig et al. (1982) polar cod numbers increased when water temperatures were decreasing and salinities were increasing after mid- August in Simpson Lagoon on Alaska`s North Slope. In the study of Gaston et al. (2003), the occurrence of polar cod decreased in the diet of nestling thick- billed murres during the period 1980-2002. This is related to real changes in fish populations, and it seems changes in the oceanography, possible driven by temperatures increases over recent decades, explain these changes best. Gjøsæther (1973) got the highest recordings of polar cod in water temperatures ranging from 0 to -1.4 ˚C during all surveys in May- June. Polar cods have been observed at greater depths when surface waters temperatures rise and trawl hauls generally gain more fish when it is taken in water temperatures below 0 ˚C (Falk- Petersen et al. 1986). Since many polar cods were caught at temperatures above 0 ˚C, Falk- Petersen et al. (1986) concluded that the specie can tolerate temperatures up to 3 ˚C and Craig et al. (1982) pointed out that polar cods are tolerant to widely fluctuating temperatures and salinities regimes. In my sampling only benthic trawling was successful in Kongsfjorden, even though hours were used in front of an echo sounder trying to detect schools of fish (Fredrik Broms, pers. comm.). As mentioned in 2.1 there was no catch of polar cod (only Atlantic cod) in the shallow (approximately 150 meters) area in the inner part of Kongsfjorden in autumn and the temperature/salinity profiles (Fig 2) reveals that temperatures of 3 ˚C were only found close to 300 meters and deeper. First at that depth the benthic trawl was successful in autumn (Table 1). This year I attended the same scientific cruise and no polar cods were caught at all in Kongsfjorden.

The proportion of empty stomachs was relatively low in my studies. Hop, Welch and Crawford (1997) found that the frequency of empty stomachs were higher in adult schools (65 %) compared with non- schooling fish (6 %) and this might suggest that polar cod in Svalbard waters are non- schooling.

The variability of stomach fullness in polar cod is high, according to Hop et al. (1997), but this assumption is not supported in my studies. My study shows that stomach fullness varied from 2.4 to 2.73 (Fig 17), a small difference. Even though this is a subjective measure and comparison between studies is not recommended, the individual variance measured by the same observer in the same study should be comparable. Since I only had benthic trawls in my study and therefore probably non- schooling fish (as suggested earlier), this “selectiveness” in sampling might explain this small difference.

There seems to be no relationship between stomach fullness and number of prey in the water column in my studies. Kongsfjorden in autumn had by far the highest number of potential prey m^{-3} (Fig 3b); yet polar cod still had the lowest degree of fullness (Fig 17). Fish from Kongsfjorden in spring had the highest degree of stomach fullness (Fig 17) and at the same time the lowest numbers of prey individual’s m^{-3} occurred (Fig 3b). As mentioned above the digestive processes are very slow in sub- zero temperatures (Hop and Tonn 1998) and when the temperature is close to zero, it seems to strongly influence the metabolic processes in polar cod (Hop and Graham 1995) so even if the food supply is abundant the slow digestive rate will limit the food intake. As a benefit, low gastric evacuation rate will retain food longer in the intestinal system, resulting in increased assimilation efficiency of the food (Hop and Tonn 1998) and lower the temperature the higher the efficiency (Hop et al. 1997). Since Kongsfjorden in spring and Billefjorden experienced the lowest temperatures (Fig 2), these metabolic responses to temperature could explain the difference shown in Fig 16.

A diet shift theory in polar cod has been proposed by several authors (Lowry and Frost 1981, Bradstreet et al. 1986, Daase et al. 2000 and Hop et al. 2002). Hop et al. (2002) proposed a diet shift at the size class 8- 10 cm from a dominance of copepods to a dominance of amphipods. This is only partly supported in my studies. The frequency of *Calanus* spp is high in all size classes, even though it looks like it might be more important in small sized polar cod. Regarding biomass and numbers it is clear that the Euphausiids and *Themisto* spp are more important for polar cod when it grows larger. Both Euphausiids and *Themisto* spp are much larger organism then *Calanus* spp and consequently an increase of these organisms in the diet will be very important in terms of biomass. The thick exoskeleton on Euphausiids and especially *Themisto* spp will reduce the amount of energy and lipid content in relation to size, compared to *Calanus* spp (Hop et al. 1997), but their large size regardless imply their importance in the diet of polar cod.

The primary importance of copepods (mostly *Calanus* spp*)*, but also amphipods (mostly *Themisto* spp) and euphausiids (mostly *Thysanoessa* spp) in the diet of polar cod is in accordance with previous studies (Bradstreet et al. 1986, Lønne and Gulliksen 1989, Aijad and Gjøsther 1990, Coyele et al. 1997, Hop et al. 1997, Craig et al. 1982, Lowry and Frost 1981). However, there are exceptions; Craig et al. (1982) and Lowry and Frost (1981) both mention mysids as a substantial part of the diet of Polar cod. Lowry and Frost (1981) findings also include shrimp as important prey. Both these studies are from areas around Alaska and Canada and there can be geographically differences either in prey availability (environment) or prey selectivity by polar cod.

In my studies the contribution by euphausiids was recorded in spring (Fig 13), while in autumn amphipods were the prevailing large prey organisms (Fig 13). This apparent diet shift in polar cod can be explained by prey availability or selectiveness towards euphausiids in spring or amphipods in autumn. My prey community studies were based on WP2 hauls, which do not provide quantitative samples of these large, fast swimming organisms, so that reliable estimates of the abundance of Euphausiidae and amphipods are not available.

Craig et al. (1982) found some evidence that polar cod prefer to eat mysids rather than amphipods when both are available, but it is unclear if the same will relate to euphausiids (instead of mysids) versus amphipods. The highly negative electivity values (-0.87 to -0.96) for amphipods found by Craig et al. (1982) suggest either the avoidance or the inaccessibility to polar cod. Lund (1981) showed that the amount of euphausiids consumed by capelin (length 13 to 16 cm) in terms of calories could vary from 28 % to 98 % of the diet during different seasons. The highest was observed in spring and the lowest in autumn. Capelin and polar cod share many of the same functions in an ecosystem as they both are a very important link in transforming energy from lower (zooplankton) to higher trophic levels. They have approximately the same size, much of the same genera serve as prey and both have pelagic life period.

Falk- Petersen et al. (2000) found that *T. inermis* is the only species of Euphausiids that are from a true Arctic origin and when analyzing the water masses present at the time of sampling (Arctic water masses) it is a reasonable assumption that *T. inermis* was the dominating Euphausiids species present. The herbivores *T. inermis* has adapted to seasonal changes in the food availability by a propensity to convert its phytoplankton diet rapidly into lipids, mainly wax esters. This makes it possible for *T. inermis* to spawn just after the onset of the spring phytoplankton bloom on the shelves and in fjords (Falk- Petersen et al., 2000). To speculate, these factors could indicate an advantage of feeding on this species in spring.

According to Dalpadado et al. (2001) the highest abundances of *Themisto* spp were recorded in summer and autumn (respectively), with *Themisto abyssorum* having a deeper distribution (> 200 m) than *Themisto libellula. T. libellula* is characterized as an Arctic species, while *T. abyssorum* predominate in subarctic waters (Delpadado, 2001). In my studies the amount of *T. libellula* in the stomach of polar cod was twice the amount of *T. abyssorum* (Appendix 1), even though the fjord was strongly influenced by Atlantic water masses (C. Griffiths, pers. comm.), which often will imply dominance of species from Atlantic origin (Willis et al, 2006). This is also suggested during my investigation. Another group on the same scientific cruise was monitoring makro- zooplankton abundances with a combination of WP3 and MIK nets over a period of 24 hour, and found a conservative ten-fold dominance of *T. abyssorum* (max ca 0.55 ind $m^{3,}$ min 0.25 ind m^3) compared to *T. libellula* (0.02 ind m^3 , 0.0 ind m^3) in the water column (Båtnes et al. 2006). The true Arcitic species *T. libellula* is, as many Arctic species, larger than congeneric species in subpolar waters. This might suggest a selective feeding behavior towards the larger Arctic form. Or it can just be an indication of pelagic feeding behavior (*T. abyssorum* having a deeper distribution) and still reflects the surrounding prey in its feeding ground and hence having an opportunistic feeding behavior.

Lund (1981) showed that the caloric importance *T. libellula* and *T. abyssorum* in the diet of Barents Sea capelin (13- 16 cm) can vary from 1- 42 %. The highest in autumn and lowest in spring and the same study showed a higher predation on amphipods by capelin in autumn. Dalpadado et al. (2001) `s results seem to indicate that capelin feed more on the smaller size *T. abyssorum* during the autumn.

Billefjorden had the least diverse prey abundances and the least diverse zooplankton community. This is in contrast with the findings of Carlens et al. (2001). They reported that the diet of polar cods in Billefjorden was more diverse compared to other fjords around Svalbard, and furthermore that krill formed a large proportion of the diet. In Billefjorden only 52 fishes were sampled (compared to around 200 in Kongsfjorden both spring and autumn) and the lower diversity could be explained by the small number of fish sampled. Polar cod caught in Billefjorden were also smaller sized compared to other stations and several authors have concluded that there is a diet shift in polar cod related to size (Daase et al 2000, Bradstreet et al 1986, Lowry and Frost 1981, Haakon Hop et al. 2002). Even though a diet shift was only vaguely suggested in my studies (see above) *Calanus* spp apparently were especially important in smaller size classes. As much as 90 % of the diet of polar cod in Billefjorden consisted of *Calanus* spp, while Pseudocalanus spp, which were the most numerous of all species in the WP2 hauls, made up ~5 % of the diet of polar cod in Billefjorden.

Calanus spp were the most numerous prey species at all stations and several studies have concluded that *Calanus* spp is important prey for polar cod (Bradstreet et al. 1986, Lønne and Gulliksen 1989, Aijad and Gjøsther 1990, Coyele et al. 1997, Hop et al. 1997, Craig et al. 1982, Lowry and Frost 1981). Hop et al. 1997 showed that fish fed maximum daily rations were affected by the type of food given. When given live Arctic zooplankton, small fish (5 g) offered maximum rations of *Calanus* spp had faster growth rates (56 mg day^{-1}) than similarly sized fish offered *Themisto* spp (38 mg day^{-1}). Similar trends were also found for the energy content in the liver for the different prey items. Fish fed to satiation on *Calanus* spp increased in weight and in energy content (stored as lipids) in the liver, while fish fed *Themisto* spp to satiation only increased in weight. These results can be explained by the higher energy and lipid content of *Calanus* spp compared to *Themisto* spp, probably because of its thicker exoskeleton. These findings by Hop et al. (1997) support a conclusion of selective feeding behavior towards *Calanus* spp for polar cod.

In waters around Svalbard three species of *Calanus* occur; *C. finmarchicus, C. glacialis* and *C. hyperboreus*. Of these species *C. glacialis* and *C. hyperborous* are of Arctic origin, while *C. finmarchicus* is of Atlantic origin. These species are known to accumulate large reserves of lipids, especially wax esters, during their life cycles (Scott et al 2000). According to Scott et al. (2000) stage V copepodites had larger reserves of lipid than stage IV copepodites in *C. glacialis* and adult females were even richer in lipids. The same results were found in *C. hyperboreus*, whereas in *C. finmarchicus* the accumulation reached maximal levels in stage V copepodites. Scott et al. (2000) found that the large *C. hyperboreus* had the highest percentages of wax esters in total lipid, *C. glacialis* the intermediate level and *C. finmarchicus* the lowest level.

In my result there is a significant difference in the prosome length of *Calanus* spp found in the surroundings and in the stomach, being bigger in the stomach both seasons in Kongsfjorden and smaller in the stomach in Billefjorden. Initially the copepodite stage for *Calanus* spp found in the stomach was noted, but very often the stage was impossible to detect due to digestive processes. The easily recognizable genital segment on the first segment of the telson for adult females might bias the data and after a high number of only adult females being identified, procedures were altered to only focus on size. The biggest difference in size was found in spring in Kongsfjorden (Fig 16, Fig 17) where polar cod had eaten *Calanus* spp approximately 0.5 mm on average longer than what was found in the surroundings. Selection for the bigger individuals is a well-known phenomenon in marine ecosystems (Floeter and Tanning (2005). Larger individuals are more visible to the predator, might reduce the handling time in a cost- benefit perspective and as mentioned above, contain a larger proportion of energy. These are all factors that could affect the feeding strategy of polar cod. The very small difference between prosome lengths found in the stomach and in the surroundings that are observed in both Kongsfjorden and Billefjorden in autumn and the fact that in Kongsfjorden bigger *Calanus* spp were eaten compared to what was found in the WP2 hauls and smaller in Billefjorden make my results inconclusive. Ajiad and Gjøsæther (1990) found that the total average weight of stomach content increased with increasing length of polar cod and they concluded that this seemed to occur by means of an increase in prey size rather than an increase in prey number. According to Bradstreet and Cross (1982) the mean length of ingested copepods correlated significantly with fish lengths offshore, but that trend was not seen in inshore polar cod. Kongsfjorden in spring, where the largest deviations from the mean prosome length were found, consisted of relatively large individuals compared to the other stations (Fig 9) and some of the difference can be explained by larger sized fish catching larger preys.

Kongsfjorden is an open fjord, with the potential for large water renewals in the course of a relatively short time. A change from southern to northern wind direction will bend the West Spitsbergen current off shore, with subsequent transport of Atlantic water up along the western coast of Spitsbergen, east into Kongsfjorden (C. Griffiths, pers. comm.). Willis et al. (2006) clearly showed a close relationship between water mass advection from the adjacent shelf into Kongsfjorden and change in zooplankton community structure associated with these events. Such events will expectedly lead to a shift in the zooplankton community structure from *Calanus glacialis* dominance (Arctic origin) to more *C. finmarchicus* dominance (Atlantic origin). From the WP2 data the amount of *C. glacialis* and *C. finmarchicus* in my studies in spring are approximately equal. Other findings from Willis et al. (2006) suggest that early in the season the Kongsfjorden is dominated by the Arctic species *C. glacialis* and a recent advection of water masses could have changed the zooplankton community structure. The polar cod in the fjords of Svalbard thus lives in a dynamic environment, where the food supply and prey composition may change on a short time scale.

References:

Bradstreet M-S-W, Finley K-J, Sekerak A-D, Griffiths W-B, Evans C-R, Fabijan M-F, Stallard H-E (1986) Aspects of the biology of Arctic cod *(B oreogadus saida)*a nd its importance in arctic marine food chains. Canadian Technical Report of Fisheries and Aquatic Sciences 1491.

Bradstreet M-S-W, Cross W-E (1982) Trophic Relationships at High Arctic Ice Edges. Arctic vol. 35, no. 1 (March 1982), P. 1-12

Båtnes A-S, Berchenko I, Noyon M, Wathne I (2006) Macrozooplankton community in Svalbard waters. AB- 320 Marine Zooplankton and sympagic fauna (=ice fauna) of Svalbard waters 36 pp

Carlens H, Hansson P, Helland I-P et al. (2001) Composition and ecology of fish species in Svalbard waters. AB-202 Marine arctic ecology. Cruise report. The university center in Svalbard. Norway. 19 pp

Christiansen J-S, Fevolden S-E. (2000) The polar cod of Porsangerfjorden, Norway; revisited. Sarsia Vol. 85 issue 3: 189

Coyle K-O, Gillispie J-A, Smith R-L, Barber W-E (1997) Food habits of four demersal Chuchki Sea fishes. In fish ecology in Arctic North America. Edited by Reynolds J. American-Fisheries-Society-Symposium 19: 310-318

Craig P-C, Griffiths W-B, Haldorson L, McElderry H. (1982) Ecological Studies of Arctic Cod (Boreogadus saida) in Beaufort Sea Coastal Water. Canadian Journal of Fisheries and Aquatic Sciences. Vol. 39 issue 3: 395

Crawford R-E, Jorgenson J-K. (1996) Quantitative studies of Arctic cod (Boreogadus saida) schools: Important energy stores in the Arctic food web. Arctic. Vol. 49 issue 2 : 181

Daase M, Dale K, Lidner E, Wold A (2000) Pelagic structure in an Arctic threshold fjord. AB- 310 Benthic ecology. Cruise report. The University center in Svalbard. Norway. 13 pp

Dalpadado P, Borkner N, Bogstad B, Mehl S (2001) Distribution of Themisto (Amphipoda) spp. in the Barents Sea and predator-prey interactions. ICES Journal of Marine Science Vol. 58 issue 4: 876

Falk-Petersen I-B, Frivoll V, Gulliksen B, Haug T (1986) Occurrence and size/age relations of polar cod, Boreogadus saida (Lepechin), in Spitsbergen coastal waters. Sarsia Vol. 71 issue 3: 3

Falk-Petersen Stig, Hagen Wilhelm, Kattner Gerhard, Clarke Andrew, Sargent John (2000) Lipids, trophic relationships, and biodiversity in Arctic and Antarctic krill. Canadian Journal of Fisheries and Aquatic Sciences Vol. 57 supplement 3: 178-191

Floeter J, Temming A (2005) Analysis of prey size preference of North Sea whiting, saithe and grey gurnard. ICES Journal of Marine Science Vol. 62 issue 5:897-907

Gaston, A-J, Woo K , Hipfner J-M (2003) Trends in Forage Fish Populations in the Northern Hudson Bay since 1981, as Dtermined from the Diet of Nestling Thick-Billed Murres, *Uria lomvia.* Auk Vol. 120 issue 2: 362- 370

Gillispie J-G,Smith R- L, Barbour, E, Barber, W-E. (1997) Distribution, abundance and growth of arctic cod in the northeastern Chukchi Sea. American-Fisheries-Society-Symposium 19: 81-89

Gjosaeter J, Bjerke O.(1973) Polar cod investigations in the Barents Sea during the summer of 1970-1972 ICES Journal of Marine Science CM F:23 pp

Gjoesaeter H, Ajiad A-M. (1990) International Counc. for the Exploration of the Sea, Copenhagen Demersal Fish Comm Growth of Polar cod (Boreogadus saida) in the Barents Sea, ICES

Gjoesaeter H, Ajiad A-M (1994) Growth of polar cod, Boreogadus saida (Lepechin), in the Barents Sea. ICES Journal of Marine Science Vol. 51 issue 1: 115

Gradinger R-R, Bluhm B-A (2004) In-situ observations on the distribution and behavior of amphipods and Arctic cod (Boreogadus saida) under the sea ice of the High Arctic Canada Basin. Polar Biology Vol. 27 issue 10: 595-603

Gradinger R-R, Meiners K, Plumley G, Zhang Q, Bluhm B-A (2005) Abundance and composition of the sea-ice meiofauna in off-shore pack ice of the Beaufort Gyre in summer 2002 and 2003. Polar-Biology Vol. 28 issue 3: 171-181

Haug T, Gulliksen J (1982) Size, age, occurrence, growth, and food of Greenland halibut, Reinhardtius hippoglossoides (Walbaum) in coastal waters of western Spitzbergen. Sarsia Vol. 67 issue 4: 293

Hognestad P-T (1968) Polar Cod, Boreogadus saida Lep, in Norwegian waters. Astarte Vol. 1:31

Hognestad P-T (1968) Observations on polar cod in the Barents sea. Rapp. P.-v. Reun. Cons. Int. Expor. Mer 158: 126-130

Hop H, Graham M (1995) Respiration of juvenile Arctic cod (Boreogadus saida): Effects of acclimation, temperature, and food intake. Polar biology Vol. 15 i 5: 359

Hop H, Welch H-E, Crawford R-E, Reynolds J-B (1997) Population structure and feeding ecology of Arctic cod schools in the Canadian High Arctic. American Fisheries Society Symposium no. 19 issue 19: 68

Hop H, Tonn W-M, Welch H-E (1997) Bioenergetics of Arctic cod (Boreogadus saida) at low temperatures. Canadian Journal of Fisheries and Aquatic Sciences Vol. 39 issue 8: 1772

Hop H, Tonn W-M (1998) Gastric evacuation rates and daily rations of Arctic cod (Boreogadus saida) at low temperatures. Polar Biology Vol. 19 issue 5: 293

Hop H, Pearson T, Hegseth E-N, Kovacs K-M, Wiencke C, Kwasniewski S, Eiane K, Mehlum F, Gulliksen B, Wlodarska-Kowalczuk M, Lydersen C, Weslawski J-M, Cochrane S, Gerland S, et al. (2002) The marine ecosystem of Kongsfjorden, Svalbard. Polar Research Vol. 21 issue 1: 167

Jensen T, Ugland K-I, Anstensrud M (1991) Aspects of growth in Arctic cod, *Boreogadus saida* (Lepechin 1773). Polar Research 10(2): 547-552.

Jobling M (1997) Temperature and growth: modulation of growth rate via temperature change. Society for Experimental Biology Seminar Series Vol. 61: 225-253

Kohler N-E, Casey J-G, Turner P-A (1995) Length-weight relationships for 13 species of sharks from the western North Atlantic. Fishery Bulletin Vol. 93 issue 2: 412

Lowry L-F, Frost K-J (1981) Distribution, growth, and foods of Arctic cod (Boreogadus saida) in the Bering, Chukchi, and Beaufort Seas. Canadian-Field-Naturalist Vol. 95 issue 2: 186- 191

Lund A (1981) Feeding ecology of capelin *Mallotus villosus villosus* Müller, in the Barents Sea. Cand real thesis (in Norwegian). Institute of Fisheries Biology, University of Bergen, Norway.

Lønne O-J, Gulliksen B (1989) Size, age and diet of polar cod Boreogadus saida (Lepechin 1773) in ice covered waters. Polar-Biology Vol. 9 issue 3: 187- 192

Lønne O-J, Gabrielsen G-W (1992) Summer diet of seabirds feeding in sea- ice-covered waters near Svalbard. Polar Biol (1992) 12: 685-692

Mehlum F, Hunt G-L, Klusek J-Z, Decker M-B, Nordlund N (1996) The importance of prey aggregations to the distribution of Brünnich's guillemots in Storfjorden, Svalbard. Polar Biol (1996) 16: 537-547

Mehlum F, Hunt G-L, Klusek J-Z, Decker M-B, Nordlund N (1998) Hydrographic Features, Cetaceans and the Foraging of Thick-Billed Murres and Other Marine Birds in the Northwestern Barents Sea. Arctic vol. 51, no. 3 (September1998) p. 243–252.

Morato T, Afonso P, Lourinho P, Barreiros J-P, Santos R-S, Nash R-D-M (2001) Length-weight relationships for 21 coastal fish species of the Azores, north-eastern Atlantic. Fisheries Research Vol. 50 issue 3: 297

Nilssen K-T, Haug T, Potelov V, Timoshenko Y-K (1994) Feeding habits of harp seals (Phoca *groenlandica)* during early summer and autumn in the northern Barents Sea Polar Biol Vol. 15:485-493

Olsen S (1962) Observations on polar cod in the Barents Sea. Mimeo, Int Coun Explor Sea, Distant Northern Seas Committee, Copenhagen

Ponomarenko V-P (1964) Study of Polar cod in the Barents sea. Annls. Boil. Copenhagen Vol. 19: 93-96

Ponomarenko V-P (1968) Some data on the distribution and migrations of polar cod in the seas of the Soviet arctic. Rapp. P. –v. Reun. Cons. Int. Explorer de la Mar 158: 135-137

Sæther B-S, Christiansen J-S, Jobling M (1999) Gastrointestinal evacuation of pArcticulate matter in polar cod Boreogadus saida. Marine Ecology Progress Series Vol. 188: 201

Scott C-L, Kwasniewski S, Falk-Petersen S, Sargent, J-R (2000) Lipids and life strategies of *Calanus finmarchicus, Calanus glacialis* and *Calanus hyperboreus* in late autumn, Kongsfjorden, Svalbard. *Polar Biol.*, 23, 510–516

Springer A-M, Roseneau D-G, Murphy E-C, Springer M-I (1984) Environmental controls of marine food webs: Food habits of seabirds in the eastern Chukchi Sea. Canadian Journal of Fisheries and Aquatic Sciences Vol. 41 issue 8: 1202

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Appendix 1: Stomach content

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 1	Spring (86)	2	1	3.44	3																	
Fisk 2	Spring (86)	3	8	3.25	2																	
Fisk 3	Spring (86)	1																				
Fisk 4	Spring (86)	2			2																	
Fisk 5	Spring (86)	1																				
Fisk 6	Spring (86)	1																				
Fisk 7	Spring (86)	2			1																	
Fisk 8	Spring (86)	2			1							1										
Fisk 9	Spring (86)	2	7	3.29								1										
Fisk 10	Spring (86)	2	1	3.75	1																	
Fisk 11	Spring (86)	1																				
Fisk 12	Spring (86)	3	12	3.42	2																	
Fisk 13	Spring (86)	2	1	3.19																		
Fisk 14	Spring (86)	1																				
Fisk 15	Spring (86)	2	1	2.38																		
Fisk 16	Spring (86)	3	10	3.21																		
Fisk 17	Spring (86)	2	3	3.48																		
Fisk 18	Spring (86)	2	1	2.88	2																	
Fisk 19	Spring (86)	3			5																	
Fisk 20	Spring (86)	3	5	3.24	6																	
Fisk 21	Spring (86)	1																				
Fisk 22	Spring (86)	2			4																	
Fisk 23	Spring (86)	2																				
Fisk 24	Spring (86)	3	3	3.17	1																	
Fisk 25	Spring (86)	4	34	3.13																		
Fisk 26	Spring (86)	1																				
Fisk 27	Spring (86)		D																			
Fisk 28	Spring (86)		D																			
Fisk 29	Spring (86)		D																			
Fisk 30	Spring (86)		D																			
Fisk 31	Spring (86)		D																			
Fisk 32	Spring (86)		D																			
Fisk 33	Spring (86)	2			1																	
Fisk 34	Spring (86)	2	2	3.34																		
Fisk 35	Spring (86)	3			7																	
Fisk 36	Spring (86)	2	3	3.83																		
Fisk 37	Spring (86)	3	4	3.56																		
Fisk 38	Spring (86)	2	2	2.84	1																	
Fisk 39	Spring (86)	4	11	3.43	10																	

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 40	Spring (86)	2	4	3.48	1																	
Fisk 41	Spring (86)	3	35	3.48																		
Fisk 42	Spring (86)	2	3	3.19	1																	
Fisk 43	Spring (86)	3	5	3.29																		
Fisk 44	Spring (86)	1																				
Fisk 45	Spring (86)	3	19	3.47																		
Fisk 46	Spring (86)	5	10	3.17																		
Fisk 47	Spring (86)	1																				
Fisk 48	Spring (86)	4	52	3.26	13																	
Fisk 49	Spring (86)	1																				
Fisk 50	Spring (86)	5	14	3.42																		
Fisk 51	Spring (86)	1																				
Fisk 52	Spring (86)	3	11	3.57	2																	
Fisk 53	Spring (86)	1																				
Fisk 54	Spring (86)	4	10	3.36																		
Fisk 55	Spring (86)	4	10	3.01	5								1									
Fisk 56	Spring (86)	3	3	3.08									2									
Fisk 57	Spring (86)	1																				
Fisk 58	Spring (86)	2	2	3.19																		
Fisk 59	Spring (86)	4	4	3.53	13																	
Fisk 60	Spring (86)	2	3	2.58				1														
Fisk 61	Spring (86)	3	4	3.03																		
Fisk 62	Spring (86)	3	13	2.95	7																	
Fisk 63	Spring (86)	3	23	3.04	5																	
Fisk 64	Spring (86)	4	45	3.28	2																	
Fisk 65	Spring (86)	1																				
Fisk 66	Spring (86)	3	9	3.10																		
Fisk 67	Spring (86)	3	9	2.81	3																	
Fisk 68	Spring (86)	2	2	3.47																		
Fisk 69	Spring (86)	2	2	2.81																		
Fisk 70	Spring (86)	1																				
Fisk 71	Spring (86)	1																				
Fisk 72	Spring (86)	4	39	3.25	10																	
Fisk 73	Spring (86)	4	25	3.21																		
Fisk 74	Spring (86)	3	9	3.52																		
Fisk 75	Spring (86)	2	1	2.31																		
Fisk 76	Spring (86)	2						1														
Fisk 77	Spring (86)	2	1	3.38																		
Fisk 78	Spring (86)	4	44	3.17	2																	
Fisk 79	Spring (86)	2																				

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 80	Spring (86)	1																				
Fisk 81	Spring (86)	4	7	3.19	16																	
Fisk 82	Spring (86)	3	2	2.84	3																	
Fisk 83	Spring (86)	3	2	3.66	6																	
Fisk 84	Spring (86)	1																				
Fisk 85	Spring (86)	4	10	3.25	14																	
Fisk 86	Spring (86)	5	116	3.39				7														
Fisk 87	Spring (86)	2	1	3.69	2																	
Fisk 88	Spring (86)	2			1																	
Fisk 89	Spring (86)	1																				
Fisk 90	Spring (86)	4	9	3.20	8																	
Fisk 91	Spring (86)	4	1	3.19	12																	
Fisk 92	Spring (86)	2	1	3.63	2																	
Fisk 93	Spring (86)	2																				
Fisk 94	Spring (86)	3	2	3.91	5																	
Fisk 95	Spring (86)	4	39	3.25	2																	
Fisk 96	Spring (86)	2	1	3.63	1																	
Fisk 97	Spring (86)	2	1	2.88																		
Fisk 98	Spring (86)	2	2	3.34																		
Fisk 1	Spring (89)	5	258	3.19	3									2	1							
Fisk 2	Spring (89)	2			2																	
Fisk 3	Spring (89)	3	17	3.12	8		1															
Fisk 4	Spring (89)	1																				
Fisk 5	Spring (89)	4	35	3.17																		
Fisk 6	Spring (89)	5	49	3.25												1						
Fisk 7	Spring (89)	3	7	3.21	21																	
Fisk 8	Spring (89)	2	4	3.44	5																	
Fisk 9	Spring (89)	2	2	3.00	4																	
Fisk 10	Spring (89)	3	8	3.30	7																	
Fisk 11	Spring (89)	2	1	3.63	9												1					
Fisk 12	Spring (89)	2			1																	
Fisk 13	Spring (89)	2	2	2.69	1		1															
Fisk 14	Spring (89)	4	37	3.21	10																	
Fisk 15	Spring (89)	3	7	2.48	2										1							
Fisk 16	Spring (89)	4	62	3.46	3		2	1														
Fisk 17	Spring (89)	3	5	2.88																		
Fisk 18	Spring (89)	2													1	2						
Fisk 19	Spring (89)	3	1	3.19	12																	
Fisk 20	Spring (89)	3	5	3.49	15																	

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 21	Spring (89)	3	13	3.57	7																	
Fisk 22	Spring (89)	2	10	3.34	2																	
Fisk 23	Spring (89)	3	9	3.25	3		1															
Fisk 24	Spring (89)	2	3	3.67	7																	
Fisk 25	Spring (89)	3	10	3.08	6																	
Fisk 26	Spring (89)	1																				
Fisk 27	Spring (89)	5	196	3.27	1																	
Fisk 28	Spring (89)	1																				
Fisk 29	Spring (89)	2	6	3.31	6	3																
Fisk 30	Spring (89)	2	5	2.65																		
Fisk 31	Spring (89)	4	52	2.90	14																	
Fisk 32	Spring (89)	3	12	3.27	1	4																
Fisk 33	Spring (89)	3	23	3.28	6																	
Fisk 34	Spring (89)	2	3	3.35	1																	
Fisk 35	Spring (89)	4	8	3.02	32																	
Fisk 36	Spring (89)	2	10	3.46	2																	
Fisk 37	Spring (89)	3	6	3.32	47																	
Fisk 38	Spring (89)	5	2	3.63	138																	
Fisk 39	Spring (89)	2	1	2.69	8																	
Fisk 40	Spring (89)	2			1																	
Fisk 41	Spring (89)	4	5	3.09	23																	
Fisk 42	Spring (89)	2	10	3.30	2																	
Fisk 43	Spring (89)	2	5	3.63	2		1															
Fisk 44	Spring (89)	3	12	3.11	3																	
Fisk 45	Spring (89)	4	12	3.34																		
Fisk 46	Spring (89)	5	24	3.39	54																	
Fisk 47	Spring (89)	3	4	3.14																		
Fisk 48	Spring (89)	2	3	3.30	3																	
Fisk 49	Spring (89)	2	1	2.06	1																	
Fisk 50	Spring (89)	5	41	3.18	88			1														
Fisk 51	Spring (89)	3	8	3.20	8																	
Fisk 52	Spring (89)	2			2																	
Fisk 53	Spring (89)	5	45	3.30	59																	
Fisk 54	Spring (89)	3	20	3.38	12																	
Fisk 55	Spring (89)	2	3	3.29																		
Fisk 56	Spring (89)	2	3	2.83																		
Fisk 57	Spring (89)	2	3	2.94																		
Fisk 58	Spring (89)	4	18	3.35	39																	
Fisk 59	Spring (89)	2	2	3.50																		
Fisk 60	Spring (89)	4	4	3.11	1						1											

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 61	Spring (89)	4	25	3.23	22																	
Fisk 62	Spring (89)	3	20	3.21	16																	
Fisk 63	Spring (89)	3	13	3.48	3		1															
Fisk 64	Spring (89)	5	40	3.29	3																	
Fisk 65	Spring (89)	3	31	3.15	1																	
Fisk 66	Spring (89)	5	15	3.32	25																	
Fisk 67	Spring (89)	4	114	3.23	9																	
Fisk 68	Spring (89)	3	7	3.41	31																	
Fisk 69	Spring (89)	3	7	3.14	9		5															
Fisk 70	Spring (89)	3	3	2.83	39																	
Fisk 71	Spring (89)	2	2	3.56	3																	
Fisk 72	Spring (89)	3	8	3.15	15																	
Fisk 73	Spring (89)	4	4	3.17	29																	
Fisk 74	Spring (89)	2	8	3.48	3																	
Fisk 75	Spring (89)	3	7	3.37	19																	
Fisk 76	Spring (89)	2	2	3.63																		
Fisk 77	Spring (89)	3	8	3.12	16																	
Fisk 78	Spring (89)	1																				
Fisk 79	Spring (89)	2	1	3.25	4																	
Fisk 80	Spring (89)	3	2	3.09	23																	
Fisk 81	Spring (89)	1																				
Fisk 82	Spring (89)	2	4	3.45																		
Fisk 83	Spring (89)	2	2	3.19	3																	
Fisk 84	Spring (89)	2	2	3.19																		
Fisk 85	Spring (89)	4	98	3.34	1																	
Fisk 87	Spring (89)	3	1	3.69	13																	
Fisk 88	Spring (89)	5	2	3.25	125																	
Fisk 89	Spring (89)	4	51	3.22	17																	
Fisk 1	Autumn (IK)	1																				
Fisk 2	Autumn (IK)	2			1			4	1													
Fisk 3	Autumn (IK)	3	29	2.82				4	2													
Fisk 4	Autumn (IK)	2	9	2.95																		
Fisk 5	Autumn (IK)	2						2	1	1												
Fisk 6	Autumn (IK)	2	6	3.15				5														
Fisk 7	Autumn (IK)	3						1	2	2												
Fisk 8	Autumn (IK)	2	5	2.94				1														
Fisk 9	Autumn (IK)	2	4	3.30																		
Fisk 10	Autumn (IK)	3	11	2.64				8														
Fisk 12	Autumn (IK)	1																				

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 13	Autumn (IK)	2	20	2.93				3														
Fisk 14	Autumn (IK)	2	4	3.02				2	2													
Fisk 15	Autumn (IK)	2	5	2.70				2														
Fisk 16	Autumn (IK)	3	11	2.70				7	2													
Fisk 17	Autumn (IK)	2	2	2.75					1	1												
Fisk 18	Autumn (IK)	2	8	2.59	1																	
Fisk 19	Autumn (IK)	2								1												
Fisk 20	Autumn (IK)	3			1			8														
Fisk 21	Autumn (IK)	2	2	2.34				11														
Fisk 22	Autumn (IK)	2						5														
Fisk 23	Autumn (IK)	3	3	2.85				6	1	1												
Fisk 24	Autumn (IK)	3	9	2.86																		
Fisk 25	Autumn (IK)	3	5.2	2.95				5	1													
Fisk 26	Autumn (IK)	2	5.4	2.77				2														
Fisk 27	Autumn (IK)	3	19	2.85					1													
Fisk 28	Autumn (IK)	2							1	1												
Fisk 29	Autumn (IK)	3	9	2.90						2						2						
Fisk 30	Autumn (IK)	2	6	2.82																		
Fisk 31	Autumn (IK)	2	7	2.72																		
Fisk 32	Autumn (IK)	3	13	2.20																		
Fisk 33	Autumn (IK)	2	5	2.74												1						
Fisk 34	Autumn (IK)	2	6	2.73						1									1			
Fisk 35	Autumn (IK)	4	1	3.81				2	2													
Fisk 36	Autumn (IK)	4	51	2.51																		
Fisk 37	Autumn (IK)	3	14	2.87																		
Fisk 38	Autumn (IK)	3	3	2.58				3	1													
Fisk 39	Autumn (IK)	2	2	2.44				5	3											1		
Fisk 40	Autumn (IK)	3	11	2.65				3	1	1												
Fisk 41	Autumn (IK)	5	13	2.88	1			5		1												
Fisk 42	Autumn (IK)	2						1														
Fisk 43	Autumn (IK)	2	7	3.24				4														
Fisk 44	Autumn (IK)	3	4	2.58				2	2	3												
Fisk 45	Autumn (IK)	2	5	2.63				1								1						
Fisk 46	Autumn (IK)	2	3	2.81														1				
Fisk 47	Autumn (IK)	2						3	2	4												
Fisk 48	Autumn (IK)	1																				
Fisk 49	Autumn (IK)	2	7	2.70				2	1													
Fisk 50	Autumn (IK)	2	3.1	2.66				2														
Fisk 51	Autumn (IK)	3	5.1	3.08																		
Fisk 52	Autumn (IK)	2	4.1	2.58				2														

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 53	Autumn (IK)	3	4	2.78				2	1	1												
Fisk 54	Autumn (IK)	3	23	2.85				1										1				
Fisk 55	Autumn (IK)	3	4	2.56				2		2												
Fisk 56	Autumn (IK)	2	4	2.88												1						
Fisk 57	Autumn (IK)	2	5	2.88												2						
Fisk 58	Autumn (IK)	3	15	2.70					2	1								1				
Fisk 59	Autumn (IK)	3	7	2.79				5	2	2												
Fisk 60	Autumn (IK)	2	2	2.63				1														
Fisk 61	Autumn (IK)	3	22	2.70																		
Fisk 62	Autumn (IK)	3	2	2.47				5	4	1												
Fisk 63	Autumn (IK)	3	2	1.94					2													
Fisk 64	Autumn (IK)	2	4.3	2.71				1	1	1												
Fisk 65	Autumn (IK)	3	7	3.35																		
Fisk 66	Autumn (IK)	2	4	4.58					4	1												
Fisk 67	Autumn (IK)	3	5	2.73				1	2													
Fisk 68	Autumn (IK)	2	5	3.29				5														
Fisk 69	Autumn (IK)	3						1	2	1								1				
Fisk 70	Autumn (IK)	3	11	2.70				1														
Fisk 71	Autumn (IK)	2	4	2.67						3												
Fisk 72	Autumn (IK)	2	6	2.69				1														
Fisk 73	Autumn (IK)	3	5	2.68	1			5	2													
Fisk 74	Autumn (IK)	3	20	2.77												4						
Fisk 75	Autumn (IK)	2	7	3.08				1	1													
Fisk 76	Autumn (IK)	2	8	2.80																		
Fisk 77	Autumn (IK)	3	10	2.04																		
Fisk 78	Autumn (IK)	2	2	2.78				1								1						
Fisk 79	Autumn (IK)	3	8	2.65				1														
Fisk 80	Autumn (IK)	2	5	3.03				1		1						1					1	
Fisk 81	Autumn (IK)	3	12	2.71				2		1										1		
Fisk 82	Autumn (IK)	2	14	2.65				1								2						
Fisk 83	Autumn (IK)	3	13	3.29												1						
Fisk 84	Autumn (IK)	3	15	2.59				2								1						
Fisk 85	Autumn (IK)	3	24	3.06				1	1													
Fisk 86	Autumn (IK)	3	8	2.80				2	2	3												
Fisk 87	Autumn (IK)	3	14	2.70						1						1						
Fisk 88	Autumn (IK)	4						1	1													
Fisk 89	Autumn (IK)	3	3	3.19				4														
Fisk 90	Autumn (IK)	3	5	2.83				8								1						
Fisk 91	Autumn (IK)	4	3	3.85	1													4				
Fisk 92	Autumn (IK)	2	4	3.01				4	4													

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 93	Autumn (IK)	2	5	2.66					1													
Fisk 94	Autumn (IK)	3	4	3.00																		
Fisk 95	Autumn (IK)	3	7	2.79				2	1	1												
Fisk 96	Autumn (IK)	2	7	2.79																		
Fisk 97	Autumn (IK)	3	12	3.14																		
Fisk 98	Autumn (IK)	1																				
Fisk 99	Autumn (IK)	3	2	2.69				7	1							1						
Fisk 100	Autumn (IK)	3	5	2.63				1														
Fisk 1	Autumn (Kb1)	3	4	2.65				3														
Fisk 2	Autumn (Kb1)	2	5	2.78																		
Fisk 3	Autumn (Kb1)	3	1	2.69	1			2														
Fisk 4	Autumn (Kb1)	2	4	2.88																		
Fisk 5	Autumn (Kb1)	3						2		1												
Fisk 6	Autumn (Kb1)	1																				
Fisk 7	Autumn (Kb1)	3	5	3.29																		
Fisk 8	Autumn (Kb1)	1																				
Fisk 9	Autumn (Kb1)	2	4	3.03																		
Fisk 10	Autumn (Kb1)	3	12	2.76												1						
Fisk 11	Autumn (Kb1)	2	1	3.19				1		1												
Fisk 12	Autumn (Kb1)	2	2	2.73																		
Fisk 13	Autumn (Kb1)	2	3	2.72																		
Fisk 14	Autumn (Kb1)	2	4	2.66																		
Fisk 15	Autumn (Kb1)	2	5	3.08																		
Fisk 16	Autumn (Kb1)	3						2														
Fisk 17	Autumn (Kb1)		5	3.09				2	1													
Fisk 18	Autumn (Kb1)	2	2	2.80																		
Fisk 19	Autumn (Kb1)	5			5			83	12	3												
Fisk 20	Autumn (Kb1)	1																				
Fisk 21	Autumn (Kb1)	2	3	3.32																		
Fisk 22	Autumn (Kb1)	1																				
Fisk 23	Autumn (Kb1)	4	4	2.54				10	5	2												
Fisk 24	Autumn (Kb1)	2	1	2.81																		
Fisk 25	Autumn (Kb1)	3	4	3.19												1						
Fisk 26	Autumn (Kb1)	2	6	2.77																		
Fisk 27	Autumn (Kb1)	3	2	3.06				1	1													
Fisk 28	Autumn (Kb1)	2	4	2.90												1						
Fisk 29	Autumn (Kb1)	2	4	2.70												3						
Fisk 30	Autumn (Kb1)	2														1						
Fisk 31	Autumn (Kb1)	3	2	2.69	5			2	2													

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 32	Autumn (Kb1)	2	3	2.63				2														
Fisk 33	Autumn (Kb1)	2	5	2.75																		
Fisk 34	Autumn (Kb1)	2						2														
Fisk 35	Autumn (Kb1)	2	2	2.59																		
Fisk 36	Autumn (Kb1)	3	12	3.16				1														
Fisk 37	Autumn (Kb1)	2	3	2.96																		1
Fisk 38	Autumn (Kb1)	2	1	3.13																		
Fisk 39	Autumn (Kb1)	2	2	2.63																		
Fisk 40	Autumn (Kb1)	3	3	3.56					1													
Fisk 41	Autumn (Kb1)	1																				
Fisk 42	Autumn (Kb1)	3	1	2.56				3														1
Fisk 43	Autumn (Kb1)	2	3	2.52																		
Fisk 44	Autumn (Kb1)	2	3	2.50																		
Fisk 46	Autumn (Kb1)	2	4	2.63																		
Fisk 46	Autumn (Kb1)	3	1	7.00				2	1									1				
Fisk 47	Autumn (Kb1)	2	1	2.63	1			1														
Fisk 48	Autumn (Kb1)	2	1	2.75												1						
Fisk 49	Autumn (Kb1)	1																				
Fisk 50	Autumn (Kb1)	1																				
Fisk 51	Autumn (Kb1)	2			1																	
Fisk 52	Autumn (Kb1)	2	1	4.06					1													
Fisk 53	Autumn (Kb1)	2	2	2.58												2						
Fisk 54	Autumn (Kb1)	3	16	2.86												1						1
Fisk 55	Autumn (Kb1)	2	4	2.83																		
Fisk 56	Autumn (Kb1)	3	4.9	2.88				1														1
Fisk 57	Autumn (Kb1)	1																				
Fisk 58	Autumn (Kb1)	2						1														
Fisk 59	Autumn (Kb1)	2	1	2.69																		
Fisk 61	Autumn (Kb1)	2	1	3.06				1	1													
Fisk 62	Autumn (Kb1)	3			2			2														
Fisk 63	Autumn (Kb1)	2	10	2.88																		
Fisk 64	Autumn (Kb1)	2	9	2.44																		1
Fisk 65	Autumn (Kb1)	3	10	2.79																		
Fisk 66	Autumn (Kb1)	2	1	2.88												2						
Fisk 67	Autumn (Kb1)	2	1	2.44																		
Fisk 68	Autumn (Kb1)	2	6	3.07																		
Fisk 69	Autumn (Kb1)	2	1	3.13				2														
Fisk 70	Autumn (Kb1)	1																				
Fisk 71	Autumn (Kb1)	1																				
Fisk 72	Autumn (Kb1)	2	2	2.66				1														

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 73	Autumn (Kb1)	2	7	2.59																		
Fisk 74	Autumn (Kb1)	2	4	3.36																		
Fisk 75	Autumn (Kb1)	3	1	2.63	1																	
Fisk 76	Autumn (Kb1)	2	3	2.69																		
Fisk 77	Autumn (Kb1)	1																				
Fisk 78	Autumn (Kb1)	4			1			2	2	2												
Fisk 79	Autumn (Kb1)	2	6	2.76																		
Fisk 80	Autumn (Kb1)	2	3	2.96																		
Fisk 81	Autumn (Kb1)	3						2														
Fisk 82	Autumn (Kb1)	4																				
Fisk 83	Autumn (Kb1)	3							2													
Fisk 84	Autumn (Kb1)	2	2	3.15																		
Fisk 85	Autumn (Kb1)	2	3	2.88																		
Fisk 86	Autumn (Kb1)	3	10	2.92																		
Fisk 87	Autumn (Kb1)	4	19	3.08																		
Fisk 88	Autumn (Kb1)	3	1	2.63																		
Fisk 89	Autumn (Kb1)	2	5	2.69																		
Fisk 90	Autumn (Kb1)	2	6	3.27																1		
Fisk 91	Autumn (Kb1)		2													1						
Fisk 92	Autumn (Kb1)	4			2				4	1												
Fisk 93	Autumn (Kb1)	2	1	3.19				1														
Fisk 94	Autumn (Kb1)	2	5	2.87																		
Fisk 95	Autumn (Kb1)	1																				
Fisk 96	Autumn (Kb1)	2	4	2.42																		
Fisk 97	Autumn (Kb1)	2						1														
Fisk 98	Autumn (Kb1)	3			1			2														
Fisk 1	Billefjord	4	31	2.78																		
Fisk 2	Billefjord	4	7	2.36	1																	
Fisk 3	Billefjord	2	13	2.68																		
Fisk 4	Billefjord	3	6	2.98																		
Fisk 5	Billefjord	2	2	3.16																		
Fisk 6	Billefjord	2	13	2.55																		
Fisk 7	Billefjord	3	23	2.75																		
Fisk 8	Billefjord	3	46	2.69																		
Fisk 9	Billefjord	3	4	2.70																		
Fisk 10	Billefjord	2	5	2.23																		
Fisk 11	Billefjord	2	5	2.52	1											1						
Fisk 12	Billefjord	2			1																	
Fisk 13	Billefjord	2	5	2.71																		

Fisk ID	Station	Degree of fullness	Num. of Calanus	Mean PL (mm)	*Thysanoessa spp*	Hyas sp	Indet	*Themisto spp*	*Themisto libellula*	*Themisto abyssorum*	Reke	Centropagidae	Fish	Kam-manet	Nauplii (Balanus	*Pseudo calanus*	Decapod larvae	Metridia spp	Oikopleura sp	Rundorm	Limacina Helicina	Cumacea
Fisk 14	Billefjord	3	3	2.97	2																	
Fisk 15	Billefjord	2	7	2.56																		
Fisk 16	Billefjord	2			1																	
Fisk 17	Billefjord		4	2.53												2						
Fisk 18	Billefjord	3	10	2.94												2						
Fisk 19	Billefjord	5	58	2.75												3						
Fisk 20	Billefjord	3	14	2.70												4						
Fisk 21	Billefjord	2	3	2.56												1						
Fisk 22	Billefjord	3	7	2.77	6			1														
Fisk 23	Billefjord	2	7	2.88	1																	
Fisk 24	Billefjord	2	3	2.33																		
Fisk 25	Billefjord	2	8	2.72																		
Fisk 26	Billefjord	2	4	2.56																		
Fis k 27	Billefjord	2	4	2.75														1				
Fisk 28	Billefjord	2	3	2.69																		
Fisk 29	Billefjord	4	21	2.71																		
Fisk 30	Billefjord	4	54	2.66												4						
Fisk 31	Billefjord	1																				
Fisk 32	Billefjord	2	2	2.53	1																	
Fisk 33	Billefjord	2	1	2.25	1											1						
Fisk 34	Billefjord	3	8	2.80				1														
Fisk 35	Billefjord	3	12	2.53																		
Fisk 36	Billefjord	4			1			8					1									
Fisk 37	Billefjord	3			2		1															
Fisk 38	Billefjord	1																				
Fisk 39	Billefjord	2	6	2.30												2						
Fisk 40	Billefjord	2	5	2.58																		
Fisk 41	Billefjord	3	5	2.73	1													1				
Fisk 42	Billefjord	2			1																	
Fisk 43	Billefjord	3	12	2.77																		
Fisk 44	Billefjord	3	1	2.63				1					1									
Fisk 45	Billefjord	3	5	2.94																		
Fisk 46	Billefjord	2	4	2.56																		
Fisk 47	Billefjord	3	15	2.72	1											3						
Fisk 48	Billefjord	2	9	2.76																		
Fisk 49	Billefjord	4	19	2.75	1			2														
Fisk 50	Billefjord	4	75	2.95	1																	
Fisk 51	Billefjord	2	2	2.69	1																	
Fisk 52	Billefjord	3	10	2.89	1													1				

Appendix 2: Length weight and age data. D weight= dry weight

Fish nr	Station	Lenght (mm)	Otolith	C weigth (g)	C+D weight	D weight(g)
1	Spring (86)	146	2	1.19	4.26	3.07
2	Spring (86)	193	3	1.34	9.76	8.42
3	Spring (86)	72	0	0.72	1.05	0.33
4	Spring (86)	195	3	1.51	8.47	6.96
5	Spring (86)	135	2	1.04	3.64	2.6
6	Spring (86)	143	2	1.11	4.28	3.17
7	Spring (86)	166	2	1.14	5.64	4.5
8	Spring (86)	155	2	1.26	5.48	4.22
9	Spring (86)	173	2	1.14	6.06	4.92
10	Spring (86)	186	3	1.27	7.82	6.55
11	Spring (86)	213	3	1.54	10.1	8.56
12	Spring (86)	82	1	0.82	1.48	0.66
13	Spring (86)	134	2	0.92	3.24	2.32
14	Spring (86)	156	2	1.25	5.18	3.93
15	Spring (86)	138	2	0.95	4.13	3.18
16	Spring (86)	136	2	1.11	3.95	2.84
17	Spring (86)	73	0	0.47	0.95	0.48
18	Spring (86)	181	3	1.42	6.52	5.1
19	Spring (86)	126	2	0.72	3.05	2.33
20	Spring (86)	87	1	0.56	1.49	0.93
21	Spring (86)	140	2	1.03	3.8	2.77
22	Spring (86)	83	1	0.54	1.19	0.65
23	Spring (86)	77	1	0.55	1.02	0.47
24	Spring (86)	77	1	0.51	0.99	0.48
25	Spring (86)	75	1	0.5	0.91	0.41
26	Spring (86)	133	2	0.81	2.92	2.11
27	Spring (86)	139	2	0.9	3.53	2.63
28	Spring (86)	146	2	1.13	5.24	4.11
29	Spring (86)	180	3	1.07	7.24	6.17
30	Spring (86)	192	3	1.32	7.73	6.41
31	Spring (86)	179	3	1.23	6.47	5.24
32	Spring (86)	149	2	1.02	4.16	3.14
33	Spring (86)	129	2	0.94	3.47	2.53
34	Spring (86)	122	2	0.92	2.59	1.67
35	Spring (86)	155	2	1.12	4.47	3.35
36	Spring (86)	191	3	1.26	8.18	6.92
37	Spring (86)	173	2	1.25	7.26	6.01
38	Spring (86)	129	2	0.61	2.7	2.09
39	Spring (86)	146	2	1.03	3.96	2.93
40	Spring (86)	153	2	1.05	4.27	3.22
41	Spring (86)	148	2	0.9	3.87	2.97
42	Spring (86)	171	2	1.12	7.13	6.01
43	Spring (86)	129	2	0.67	2.74	2.07

44	Spring (86)	147	2	0.83	3.47	2.64
45	Spring (86)	141	2	1.05	4.2	3.15
46	Spring (86)	143	2	1	4.02	3.02
47	Spring (86)	156	2	1.11	5.1	3.99
48	Spring (86)	91	1	0.59	1.6	1.01
49	Spring (86)	126	2	0.75	2.87	2.12
50	Spring (86)	131	2	0.79	3.06	2.27
51	Spring (86)	138	2	1.08	4.3	3.22
52	Spring (86)	135	2	0.89	3.13	2.24
53	Spring (86)	97	1	0.59	1.96	1.37
54	Spring (86)	146	2	0.96	4.44	3.48
55	Spring (86)	135	2	0.82	3.01	2.19
56	Spring (86)	149	2	1.08	4.77	3.69
57	Spring (86)	155	2	1.16	4.85	3.69
58	Spring (86)	158	2	1.07	4.65	3.58
59	Spring (86)	158	2	1.03	5.8	4.77
60	Spring (86)	169	2	1.07	6.79	5.72
61	Spring (86)	138	2	1.14	4.12	2.98
62	Spring (86)	160	2	1.25	6.36	5.11
63	Spring (86)	132	2	0.79	3.2	2.41
64	Spring (86)	89	1	0.56	1.34	0.78
65	Spring (86)	84	1	0.48	1.06	0.58
66	Spring (86)	86	1	0.68	1.31	0.63
67	Spring (86)	92	1	0.59	1.57	0.98
68	Spring (86)	81	1	0.57	1.16	0.59
69	Spring (86)	69	1	0.43	0.81	0.38
70	Spring (86)	89	1	0.58	1.25	0.67
71	Spring (86)	131	2	0.72	3.1	2.38
72	Spring (86)	185	3	1.4	7.34	5.94
73	Spring (86)	174	2	1.01	5.41	4.4
74	Spring (86)	146	2	0.82	4.98	4.16
75	Spring (86)	139	2	0.81	3.43	2.62
76	Spring (86)	148	2	0.9	5.51	4.61
77	Spring (86)	143	2	0.91	3.94	3.03
78	Spring (86)	176	3	0.94	6.5	5.56
79	Spring (86)	180	3	1.28	7.75	6.47
80	Spring (86)	84	1	0.63	1.15	0.52
81	Spring (86)	143	2	0.98	3.99	3.01
82	Spring (86)	138	2	0.95	3.77	2.82
83	Spring (86)	151	2	0.91	4.33	3.42
84	Spring (86)	129	2	0.84	2.59	1.75
85	Spring (86)	138	2	0.81	3.27	2.46
86	Spring (86)	139	2	0.91	3.95	3.04
87	Spring (86)	149	2	0.81	4.51	3.7
88	Spring (86)	139	2	0.81	2.95	2.14

89	Spring (86)	144	2	1.02	4.23	3.21
90	Spring (86)	134	2	0.93	3.45	2.52
91	Spring (86)	148	2	1.01	4.79	3.78
92	Spring (86)	120	2	0.85	2.74	1.89
93	Spring (86)	133	2	0.84	3.65	2.81
94	Spring (86)	168	2	1.1	5.38	4.28
95	Spring (86)	140	2	0.77	3.66	2.89
96	Spring (86)	141	2	0.77	3.88	3.11
97	Spring (86)	84	1	0.85	1.41	0.56
98	Spring (86)	85	1	0.76	1.34	0.58
99	Spring (86)	134	2	0.79	3.33	2.54
100	Spring (86)	127	2	0.75	3.59	2.84
1	Spring (89)	123	2	2.06	4	1.94
2	Spring (89)	91	1	2.31	3.09	0.78
3	Spring (89)	79	1	1.55	2.13	0.58
4	Spring (89)	141	2	1.9	4.9	3
5	Spring (89)	83	1	1.02	1.79	0.77
6	Spring (89)	112	2	1.36	3.27	1.91
7	Spring (89)	111	2	1.43	2.82	1.39
8	Spring (89)	120	2	1.32	3.72	2.4
9	Spring (89)	112	2	1.13	2.54	1.41
10	Spring (89)	88	1	1.51	2.48	0.97
11	Spring (89)	87	1	0.86	1.82	0.96
12	Spring (89)	105	1	0.99	2.88	1.89
13	Spring (89)	76	1	1.34	1.88	0.54
14	Spring (89)	117	2	1.4	3.4	2
15	Spring (89)	81	1	0.88	1.53	0.65
16	Spring (89)	137	2	1.06	4.2	3.14
17	Spring (89)	100	1	0.78	2.19	1.41
18	Spring (89)	77	1	0.78	1.2	0.42
19	Spring (89)	117	2	1.33	3.72	2.39
20	Spring (89)	146	2	1.6	5.79	4.19
21	Spring (89)	111	2	1.17	3.26	2.09
22	Spring (89)	121	2	1.13	3.22	2.09
23	Spring (89)	128	2	1.54	3.9	2.36
24	Spring (89)	74	1	0.7	1.18	0.48
25	Spring (89)	76	1	0.9	1.47	0.57
26	Spring (89)	114	2	1.57	2.93	1.36
27	Spring (89)	127	2	1.36	3.28	1.92
28	Spring (89)	131	2	1.76	4.36	2.6
29	Spring (89)	117	2	0.91	2.92	2.01
30	Spring (89)	83	1	0.86	1.43	0.57
31	Spring (89)	141	2	1.28	3.9	2.62
32	Spring (89)	73	1	0.77	1.19	0.42
33	Spring (89)	96	1	0.76	1.8	1.04

34	Spring (89)	134	2	1.41	4.1	2.69
35	Spring (89)	143	2	1.44	5.05	3.61
36	Spring (89)	147	2	1.29	4.55	3.26
37	Spring (89)	136	2	1.38	4.57	3.19
38	Spring (89)	160	3	1.6	6.33	4.73
39	Spring (89)	137	2	1.6	4.05	2.45
40	Spring (89)	117	2	1.19	2.94	1.75
41	Spring (89)	116	2	1.21	3.24	2.03
42	Spring (89)	162	3	1.75	6.53	4.78
43	Spring (89)	120	2	0.84	2.61	1.77
44	Spring (89)	91	1	1.14	1.95	0.81
45	Spring (89)	119	2	1.09	2.93	1.84
46	Spring (89)	135	2	1.11	4.01	2.9
47	Spring (89)	171	3	1.26	7.15	5.89
48	Spring (89)	139	2	1.44	4.54	3.1
49	Spring (89)	50	0	0.28	0.43	0.15
50	Spring (89)	147	2	1.27	4.5	3.23
51	Spring (89)	86	1	1.06	1.77	0.71
52	Spring (89)	145	2	1.22	3.96	2.74
53	Spring (89)	177	3	1.33	6.5	5.17
54	Spring (89)	143	2	1.16	4.27	3.11
55	Spring (89)	128	2	1.14	3.12	1.98
56	Spring (89)	146	2	1.28	4.31	3.03
57	Spring (89)	119	2	1	2.5	1.5
58	Spring (89)	106	1	0.83	2.03	1.2
59	Spring (89)	137	2	0.85	3.53	2.68
60	Spring (89)	179	3	1.38	7.33	5.95
61	Spring (89)	134	2	1.07	3.59	2.52
62	Spring (89)	137	2	1.15	3.66	2.51
63	Spring (89)	76	1	0.47	1.03	0.56
64	Spring (89)	134	2	1.02	3.85	2.83
65	Spring (89)	82	1	0.62	1.38	0.76
66	Spring (89)	155	2	1.19	5.24	4.05
67	Spring (89)	126	2	1.08	3.5	2.42
68	Spring (89)	159	2	1.28	5.16	3.88
69	Spring (89)	131	2	1.14	3.63	2.49
70	Spring (89)	137	2	0.97	3.88	2.91
71	Spring (89)	122	2	1.13	3.69	2.56
72	Spring (89)	123	2	1.04	2.94	1.9
73	Spring (89)	150	2	1.21	5.53	4.32
74	Spring (89)	156	2	1.08	4.69	3.61
75	Spring (89)	131	2	1.09	3.58	2.49
76	Spring (89)	131	2	1.32	4.02	2.7
77	Spring (89)	87	1	0.48	1.46	0.98
78	Spring (89)	133	2	0.97	4.13	3.16

79	Spring (89)	169	3	1.17	5.61	4.44
80	Spring (89)	132	2	0.83	3.36	2.53
81	Spring (89)	177	3	1.48	7.08	5.6
82	Spring (89)	146	2	1.09	4.71	3.62
83	Spring (89)	191	3	1.3	9.5	8.2
84	Spring (89)	149	2	1	4.28	3.28
85	Spring (89)	87	1	0.97	1.68	0.71
86	Spring (89)	127	2	1.11	3.55	2.44
87	Spring (89)	168	3	1.33	6.39	5.06
88	Spring (89)	156	2	1.22	5.41	4.19
89	Spring (89)	129	2	1.16	3.41	2.25
1	Autumn (IK)	120	1	0.84	3.3	2.46
2	Autumn (IK)	184	3	0.89	10.33	9.44
3	Autumn (IK)	186	3	1.32	10.37	9.05
4	Autumn (IK)	161	2	0.8	5.85	5.05
5	Autumn (IK)	133	1	0.7	3.9	3.2
6	Autumn (IK)	113	1	0.84	2.57	1.73
7	Autumn (IK)	117	1	0.83	2.89	2.06
8	Autumn (IK)	111	1	0.8	2.39	1.59
9	Autumn (IK)	197	3	1.09	9.7	8.61
10	Autumn (IK)	155	2	0.86	4.96	4.1
11	Autumn (IK)	144	1	0.91	5.65	4.74
12	Autumn (IK)	170	2	0.95	6.99	6.04
13	Autumn (IK)	179	2	1.13	9.22	8.09
14	Autumn (IK)	104	1	0.77	2.17	1.4
15	Autumn (IK)	122	1	1.02	3.16	2.14
16	Autumn (IK)	154	2	1	6.1	5.1
17	Autumn (IK)	170	2	0.99	7.63	6.64
18	Autumn (IK)	184	2	1.37	9.37	8
19	Autumn (IK)	99	1	0.63	1.7	1.07
20	Autumn (IK)	111	1	0.57	2.24	1.67
21	Autumn (IK)	119	1	0.53	2.52	1.99
22	Autumn (IK)	114	1	0.61	2.44	1.83
23	Autumn (IK)	156	2	1.1	7.74	6.64
24	Autumn (IK)	181	2	1.04	10.19	9.15
25	Autumn (IK)	161	2	1.21	7.3	6.09
26	Autumn (IK)	160	2	1.11	7.67	6.56
27	Autumn (IK)	166	2	1.1	7.87	6.77
28	Autumn (IK)	123	1	0.99	3.73	2.74
29	Autumn (IK)	124	1	0.87	3.18	2.31
30	Autumn (IK)	132	1	0.76	3.8	3.04
31	Autumn (IK)	126	1	0.7	3.4	2.7
32	Autumn (IK)	62	0	0.31	0.57	0.26
33	Autumn (IK)	138	1	0.86	4.64	3.78
34	Autumn (IK)	166	2	0.79	7.27	6.48

35	Autumn (IK)	127	1	0.9	3.65	2.75
36	Autumn (IK)	63	0	0.39	0.69	0.3
37	Autumn (IK)	159	2	0.91	6.46	5.55
38	Autumn (IK)	120	1	0.85	3.44	2.59
39	Autumn (IK)	122	1	0.82	3.3	2.48
40	Autumn (IK)	125	1	0.8	3.15	2.35
41	Autumn (IK)	116	1	0.72	2.95	2.23
42	Autumn (IK)	110	1	0.6	2.28	1.68
43	Autumn (IK)	123	1	0.72	3.06	2.34
44	Autumn (IK)	116	1	0.72	2.59	1.87
45	Autumn (IK)	107	1	0.52	2.07	1.55
46	Autumn (IK)	171	2	0.82	8.85	8.03
47	Autumn (IK)	97	0	0.61	1.6	0.99
48	Autumn (IK)	131	1	0.68	3.52	2.84
49	Autumn (IK)	126	1	0.75	3.28	2.53
50	Autumn (IK)	135	1	0.74	3.94	3.2
51	Autumn (IK)	146	2	0.81	4.73	3.92
52	Autumn (IK)	106	1	0.47	1.95	1.48
53	Autumn (IK)	187	2	1.18	11.59	10.41
54	Autumn (IK)	120	1	0.68	3.04	2.36
55	Autumn (IK)	105	1	0.57	2.11	1.54
56	Autumn (IK)	110	1	0.49	1.99	1.5
57	Autumn (IK)	121	1	0.8	2.75	1.95
58	Autumn (IK)	129	1	0.8	3.76	2.96
59	Autumn (IK)	125	1	0.54	2.93	2.39
60	Autumn (IK)	119	1	0.69	2.43	1.74
61	Autumn (IK)	128	1	0.8	3.71	2.91
62	Autumn (IK)	127	1	0.81	3.92	3.11
63	Autumn (IK)	113	1	0.69	2.54	1.85
64	Autumn (IK)	117	1	0.75	2.65	1.9
65	Autumn (IK)	145	2	0.83	4.66	3.83
66	Autumn (IK)	132	1	0.75	3.84	3.09
67	Autumn (IK)	117	1	0.68	2.97	2.29
68	Autumn (IK)	108	1	0.62	2.26	1.64
69	Autumn (IK)	124	1	0.77	3.45	2.68
70	Autumn (IK)	137	1	0.67	4.3	3.63
71	Autumn (IK)	110	1	0.61	2.38	1.77
72	Autumn (IK)	118	1	0.64	2.42	1.78
73	Autumn (IK)	130	1	0.82	3.73	2.91
74	Autumn (IK)	130	1	0.69	3.65	2.96
75	Autumn (IK)	190	2	1.2	11.45	10.25
76	Autumn (IK)	60	0	0.22	0.51	0.29
77	Autumn (IK)	66	0	0.25	0.58	0.33
78	Autumn (IK)	111	1	0.64	2.56	1.92
79	Autumn (IK)	143	1	0.76	4.31	3.55

80	Autumn (IK)	120	1	0.61	3.05	2.44
81	Autumn (IK)	124	1	0.64	3.23	2.59
82	Autumn (IK)	134	1	0.61	3.62	3.01
83	Autumn (IK)	124	1	0.74	2.9	2.16
84	Autumn (IK)	155	2	0.86	6.54	5.68
85	Autumn (IK)	121	1	0.65	2.97	2.32
86	Autumn (IK)	163	2	0.8	7.5	6.7
87	Autumn (IK)	128	1	0.66	3.1	2.44
88	Autumn (IK)	116	1	0.42	2.36	1.94
89	Autumn (IK)	206	2	1.17	14.76	13.59
90	Autumn (IK)	181	2	1.02	11.01	9.99
91	Autumn (IK)	186	2	1.11	10.5	9.39
92	Autumn (IK)	180	2	1.02	7.07	6.05
93	Autumn (IK)	123	1	0.73	2.91	2.18
94	Autumn (IK)	132	1	0.78	3.59	2.81
95	Autumn (IK)	130	1	0.72	3.75	3.03
96	Autumn (IK)	137	1	0.82	3.87	3.05
97	Autumn (IK)	168	2	0.87	8.71	7.84
98	Autumn (IK)	116	1	0.48	2.56	2.08
99	Autumn (IK)	125	1	0.69	3.29	2.6
100	Autumn (IK)	120	1	0.83	3.01	2.18
1	Autumn (KB1)	133	1	0.77	3.49	2.72
2	Autumn (KB1)	121	1	0.64	2.59	1.95
3	Autumn (KB1)	156	2	0.77	5.87	5.1
4	Autumn (KB1)	165	2	0.84	8.82	7.98
5	Autumn (KB1)	123	1	0.71	2.93	2.22
6	Autumn (KB1)	222	3	1.09	16.89	15.8
7	Autumn (KB1)	163	2	0.89	7.03	6.14
8	Autumn (KB1)	111	1	0.48	2.4	1.92
9	Autumn (KB1)	184	2	1.09	10.16	9.07
10	Autumn (KB1)	155	2	0.77	6.25	5.48
11	Autumn (KB1)	150	2	0.78	6.97	6.19
12	Autumn (KB1)	121	1	0.47	2.54	2.07
13	Autumn (KB1)	187	2	0.89	8.02	7.13
14	Autumn (KB1)	128	1	0.77	3.65	2.88
15	Autumn (KB1)	170	2	0.84	6.12	5.28
16	Autumn (KB1)	119	1	0.84	2.9	2.06
17	Autumn (KB1)	172	2	0.95	7.7	6.75
18	Autumn (KB1)	122	1	0.67	2.75	2.08
19	Autumn (KB1)	164	2	0.85	6.25	5.4
20	Autumn (KB1)	120	1	0.67	3.09	2.42
21	Autumn (KB1)	101	1	0.57	1.79	1.22
22	Autumn (KB1)	98	1	0.32	1.57	1.25
23	Autumn (KB1)	116	1	0.69	2.45	1.76
24	Autumn (KB1)	107	1	0.63	2.22	1.59

25	Autumn (KB1)	174	2	1.05	9.95	8.9
26	Autumn (KB1)	159	2	0.01	7.61	7.6
27	Autumn (KB1)	129	1	0.74	3.14	2.4
28	Autumn (KB1)	124	1	0.73	3.42	2.69
29	Autumn (KB1)	111	1	0.52	2.08	1.56
30	Autumn (KB1)	114	1	0.53	2.22	1.69
31	Autumn (KB1)	135	1	0.81	4.35	3.54
32	Autumn (KB1)	129	1	0.71	3.71	3
33	Autumn (KB1)	117	1	0.56	2.68	2.12
34	Autumn (KB1)	104	1	0.54	2.02	1.48
35	Autumn (KB1)	172	2	0.79	8.2	7.41
36	Autumn (KB1)	171	2	0.87	8.4	7.53
37	Autumn (KB1)	127	1	0.55	3.09	2.54
38	Autumn (KB1)	107	1	0.52	2.04	1.52
39	Autumn (KB1)	131	1	0.8	4.12	3.32
40	Autumn (KB1)	177	2	0.9	8.9	8
41	Autumn (KB1)	123	1	0.66	3.44	2.78
42	Autumn (KB1)	122	1	0.63	2.86	2.23
43	Autumn (KB1)	120	1	0.9	3.09	2.19
44	Autumn (KB1)	120	1	0.72	2.75	2.03
45	Autumn (KB1)	106	1	0.52	1.83	1.31
46	Autumn (KB1)	109	1	0.49	2.18	1.69
47	Autumn (KB1)	112	1	0.7	2.28	1.58
48	Autumn (KB1)	107	1	0.44	1.85	1.41
49	Autumn (KB1)	95	1	0.57	1.53	0.96
50	Autumn (KB1)	86	1	0.39	1.18	0.79
51	Autumn (KB1)	233	3	1.34	27.25	25.91
52	Autumn (KB1)	119	1	0.65	2.59	1.94
53	Autumn (KB1)	118	1	0.62	2.59	1.97
54	Autumn (KB1)	141	1	0.62	4.11	3.49
55	Autumn (KB1)	107	1	0.49	1.91	1.42
56	Autumn (KB1)	168	2	0.76	7.76	7
57	Autumn (KB1)	116	1	0.69	8.1	7.41
58	Autumn (KB1)	127	1	0.59	3.34	2.75
59	Autumn (KB1)	112	1	0.6	2.18	1.58
60	Autumn (KB1)	168	2	1.04	8.18	7.14
61	Autumn (KB1)	102	1	0.66	2.01	1.35
62	Autumn (KB1)	183	2	1.07	8.97	7.9
63	Autumn (KB1)	122	1	0.78	3.38	2.6
64	Autumn (KB1)	122	1	0.68	3.13	2.45
65	Autumn (KB1)	126	1	0.69	3.24	2.55
66	Autumn (KB1)	119	1	0.62	2.54	1.92
67	Autumn (KB1)	119	1	0.63	2.72	2.09
68	Autumn (KB1)	171	2	0.87	8.01	7.14
69	Autumn (KB1)	164	2	0.96	8.27	7.31

70	Autumn (KB1)	115	1	0.54	2.67	2.13
71	Autumn (KB1)	112	1	0.48	1.96	1.48
72	Autumn (KB1)	92	1	0.43	1.32	0.89
73	Autumn (KB1)	164	2	1.11	8.47	7.36
74	Autumn (KB1)	135	1	0.83	4.32	3.49
75	Autumn (KB1)	195	3	1.06	10.8	9.74
76	Autumn (KB1)	132	1	0.75	3.66	2.91
77	Autumn (KB1)	119	1	0.69	2.87	2.18
78	Autumn (KB1)	131	1	0.68	3.51	2.83
79	Autumn (KB1)	134	1	0.74	4.02	3.28
80	Autumn (KB1)	152	2	0.8	6.57	5.77
81	Autumn (KB1)	126	1	0.67	3.65	2.98
82	Autumn (KB1)	121	1	0.64	2.85	2.21
83	Autumn (KB1)	135	1	0.57	3.6	3.03
84	Autumn (KB1)	159	2	0.8	6.3	5.5
85	Autumn (KB1)	126	1	0.66	3.44	2.78
86	Autumn (KB1)	123	1	0.61	3.18	2.57
87	Autumn (KB1)	166	2	0.75	7.43	6.68
88	Autumn (KB1)	189	2	1.19	9.73	8.54
89	Autumn (KB1)	184	2	0.87	8.72	7.85
90	Autumn (KB1)	171	2	1.24	7.93	6.69
91	Autumn (KB1)	113	1	0.51	2.67	2.16
92	Autumn (KB1)	109	1	0.48	1.93	1.45
93	Autumn (KB1)	103	1	0.49	1.78	1.29
94	Autumn (KB1)	169	2	0.83	6.86	6.03
95	Autumn (KB1)	115	1	0.56	2.36	1.8
96	Autumn (KB1)	108	1	0.54	2.14	1.6
97	Autumn (KB1)	107	1	0.6	2.29	1.69
98	Autumn (KB1)	96	1	0.36	1.55	1.19
1	Billefjord	106	1	0.69	1.94	1.25
2	Billefjord	98	1	0.61	1.74	1.13
3	Billefjord	87	1	0.3	0.99	0.69
4	Billefjord	82	1	0.28	1	0.72
5	Billefjord	84	1	0.29	1.15	0.86
6	Billefjord	97	1	0.43	1.59	1.16
7	Billefjord	101	1	0.46	1.53	1.07
8	Billefjord	91	1	0.47	1.37	0.9
9	Billefjord	78	1	0.35	0.85	0.5
10	Billefjord	142	2	0.9	5.16	4.26
11	Billefjord	100	1	0.54	1.8	1.26
12	Billefjord	85	1	0.38	1.09	0.71
13	Billefjord	84	1	0.28	0.95	0.67
14	Billefjord	96	1	0.35	1.3	0.95
15	Billefjord	89	1	0.44	1.38	0.94
16	Billefjord	91	1	0.23	1.04	0.81

17	Billefjord	91	1	0.34	1.22	0.88
18	Billefjord	84	1	0.24	0.83	0.59
19	Billefjord	89	1	0.42	1.18	0.76
20	Billefjord	93	1	0.47	1.59	1.12
21	Billefjord	82	1	0.31	0.87	0.56
22	Billefjord	100	1	0.42	1.71	1.29
23	Billefjord	84	1	0.3	1.02	0.72
24	Billefjord	96	1	0.47	1.51	1.04
25	Billefjord	84	1	0.43	1.17	0.74
26	Billefjord	86	1	0.47	1.19	0.72
27	Billefjord	78	0	0.34	0.91	0.57
28	Billefjord	84	1	0.32	1.01	0.69
29	Billefjord	113	1	0.7	2.62	1.92
30	Billefjord	92	1	0.44	1.4	0.96
31	Billefjord	79	1	0.4	1.06	0.66
32	Billefjord	76	0	0.29	0.73	0.44
33	Billefjord	86	1	0.41	1.2	0.79
34	Billefjord	104	1	0.53	1.74	1.21
35	Billefjord	88	1	0.51	1.32	0.81
36	Billefjord	156	4	2.44	6.45	4.01
37	Billefjord	164	4	0.83	5.03	4.2
38	Billefjord	93	1	0.42	1.28	0.86
39	Billefjord	79	1	0.38	1.17	0.79
40	Billefjord	78	1	0.42	0.95	0.53
41	Billefjord	89	1	0.36	1.08	0.72
42	Billefjord	78	1	0.31	0.91	0.6
43	Billefjord	80	1	0.32	0.97	0.65
44	Billefjord	112	1	0.61	2.21	1.6
45	Billefjord	70	1	0.32	0.81	0.49
46	Billefjord	88	1	0.36	1.25	0.89
47	Billefjord	103	1	0.58	1.99	1.41
48	Billefjord	93	1	0.55	1.42	0.87
49	Billefjord	143	3	0.76	4.17	3.41
50	Billefjord	139	2	0.8	4.9	4.1
51	Billefjord	85	1	0.34	1.29	0.95
52	Billefjord	88	1	0.49	1.37	0.88